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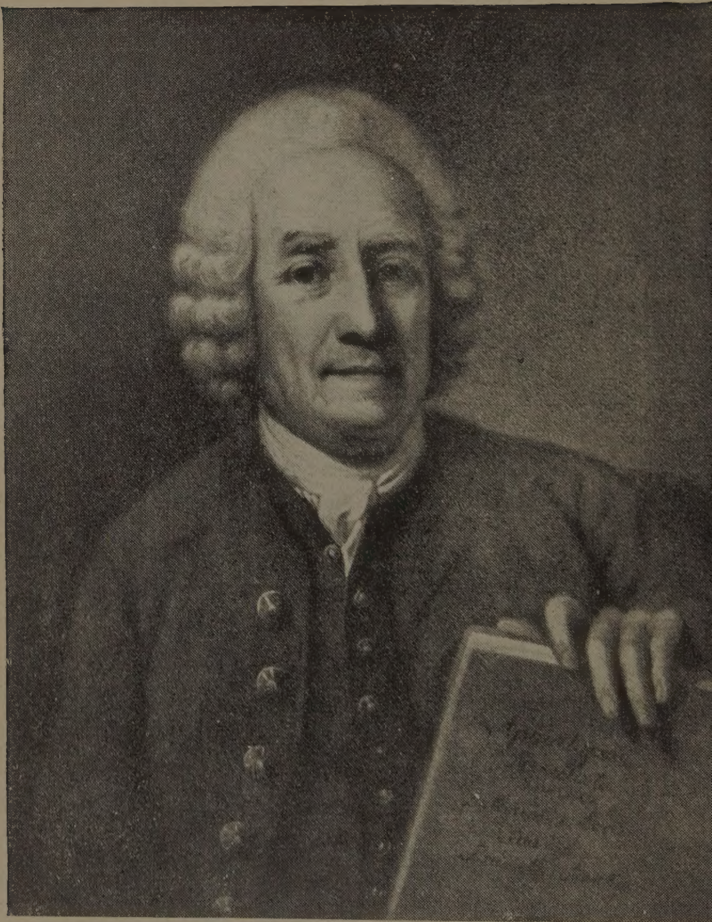

Emanuel Swedenborg

AN EPITOME OF SWEDENBORG'S SCIENCE

BY

FRANK W. VERY, S.B. (Mass. Inst. Tech.)
Member of the American Astronomical Society

In Two Volumes
VOLUME I

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DEDICATION

In his *Principia* Swedenborg says:

"Truth is my single aim; and if any friend will educe from his treasury of knowledge a juster and truer representation of the subjects in hand his kindness in so doing will be esteemed a most acceptable service."

Beloved Teacher and Friend!

In the spirit of your words I approach my task. If I have ventured to criticize your teachings in some respects, I am assured by your noble words that you would not ask me to do otherwise,—

for the sake of sacred truth.

Some mistakes you have made. Far greater are the truths you have seen. In all humility I admit that doubtless I, too, have made mistakes. In years to come this work will necessarily have to be revised by other hands. It is because Science is a live and growing plant, that it puts off its old leaves and clothes itself with new.

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AN EPITOME OF SWEDENBORG'S SCIENCE

INTRODUCTION

SWEDENBORG'S SCIENCE AND ITS RELATION TO THE SCIENCE OF TODAY

THOSE who have never studied Swedenborg's science, or who, having attempted its study, have been repelled by the intricacy of some of his ideas, or by unfamiliarity with his language and consequent doubt as to its precise meaning, may have difficulty in conceiving that there can be any use in going back nearly two centuries to read works which must seem to them to be the antiquated relics of a bygone age, completely left behind in the wonderful scientific progress of the last century. But if there be such persons, they must be prepared to learn that there are exceptions to all rules, and Swedenborg is one of them. For while other scientific theories of that distant time have been largely laid on the shelf, some of his ideas are just beginning to come to their own, and are receiving unexpected confirmation, either as a whole, or in part.

It is surprising how *"modern"* some of Swedenborg's theories are. The idea of an atom is as old as Democritus, but this was supposed to be the limit of the possible division of matter. Swedenborg, on the contrary, asserted that there were particles having different orders of magnitude, and that these were moving with great rapidity inside the aforesaid particles which previously had been thought of as somehow solid, as well as infinitely resistant and indivisible. Thus he taught that a particle of the element, air, might consist of 10,000 or 100,000 moving particles of a finer order, and these in turn of as many particles of a still finer order. Everywhere he saw motion and energy. The first part of this proposition is completely verified today. We now know that the atom is composed of many thousands of electrons, and that these are in extremely rapid orbital motion within the atom; and it is a safe guess that the electron will be shown to be formed of still finer moving particles. Already certain electrical properties are known which can best be explained on this hypothesis.

Swedenborg limited this sequence of particles to three orders, this being indicated by his great philosophic principle that throughout nature,—and as he afterwards found, in the spiritual world as well,—all things exist in trinal systems of successive derivation. The confirmation of this idea by facts known to him and by multitudes of others which have been discovered and firmly established in recent times, is simply marvelous.

Take such a simple thing as the skin or covering of a seed. It is best studied in its earliest stages in the ovule, where it consists of an outer coat, or primine; a middle coat, or secundine; and an inner coat, or tercine; the triple coat opening by a pore at the summit, called the micropyle, through which the fertilizing pollen-tube enters to communicate its virtues to the embryo which floats in the embryonic sack. The latter is the germ of the seed itself, protected by its triple coat. Sometimes one of these three coats may be wanting, or represented by a rudiment, but never are there more than three. Spiritually, three represent what is complete—in the case of the triple seed-coat, complete protection of the vital embryo.

Again, taking a cross-section of a small nerve, we find an outer sheath of perineurium, which is rather apt to consist of three layers of connective tissue, within which float on a bed of soft lymph about a dozen or twenty bundles of medullated nerve fiber, each bundle separated from the others by subordinate sheaths of connective tissue. A bundle consists of a dozen or twenty medullated nerve-fibers in the given example, each fiber composed of a medullary sheath and an axis-cylinder, or tiny rod of gelatinous nerve substance whose rapidly transiting chemical transformations are supposed to constitute the nerve-current, conveying to the central station in the brain an impetus which gives sensation to the inmost sentient cells, or in the reverse passage transmits the messages of control to the muscles or other organs. Here, again, we find a three-fold structure, but it is constitutional, and not simply protective. There is here a fundamental triple structure, consisting of (1) the nerve, (2) the bundles, and (3) the medullated fibers.

To Swedenborg we owe the conception that there is a trine in the blood; three kinds, or successive degrees of the vital fluid in the body; namely, the red blood, the lymph, and the animal spirit, or nerve-fluid; together with their three systems of vessels—the blood vessels, or circulatory system of arteries and veins, the lymphatics, and the medullated nerve-fibers which appear to furnish to the blood, perhaps by some capillary exudation, a peculiar vitalizing fluid. To-day may we not see a further trine in the red blood itself? I think we may say that these three systems have their messengers, or representatives in the lowest degree of the blood, which is a complex of all three, in that the special messenger of the red blood is the blood-disk with its hemoglobin carrying oxygen to all parts of the body. Besides the red disks there are the leucocytes, the purifiers of the blood, which are the representatives of the lymphatic system, and the blood plaques which are the direct representatives of the brain, the vitalizers of the blood, full of energy and motion, almost, as it were, free brain cells.

These things of the body are described at greater length in Swedenborg's anatomical writings, but are found summed up in *Divine Love and Wisdom,* n. 190. This passage illustrates how necessary it is for students of spiritual philosophy to have a knowledge of natural science. Without a clear picture of the triple structures of their several sorts, the reader remains in mere abstractions which have no basis in reality.

It was because Swedenborg was continually striving to apply his knowledge practically, that he was led into discoveries and inventions, either accomplished, or carefully thought out. Among these we find the design and actual construction of the first ship-railway; the invention and construction of the first mercury vacuum-pump; plans for a submarine boat and a flying machine which bring his active thought right down to the present time and the late war. These were defective because there was then no known way of constructing a motor of sufficient power to run them, but otherwise showed a general knowledge of principles and uncommon fertility of inventive genius. As a metallurgist, he publishes large treatises on the metallurgy of iron and copper, the first of their kind, and thus lays the foundation of Sweden's greatness in these arts.

In the domain of cosmical and physical conceptions, at a time when everybody believed that the world was instantaneously spoken into existence by divine fiat a few thousand years ago, Swedenborg declares that the Earth and planets have been thrown off from the sun by centrifugal force, that they have gradually moved outward along progressively widening spiral paths to their present positions, a view which is much to be preferred to Laplace's suggestion that the sun contracted and left the planets behind. In addition to this he foresees an evolution, or development of the Earth through successive states beginning with an age of fire and continuing through various stages of cooling to an equable and mild climate favorable for plant and animal creations. He discovers the bones of a whale at a considerable height above sea level, and argues that the sea must have formerly been at this height, though he surmises that this may have been due to the higher tides in the earlier ages, which was a bad guess. The tides were, indeed, higher in the *very* early ages, because the Moon was then nearer to the Earth; but that was long before any known geologic records, and the elevation of marine beds is to be ascribed to the bending and upheaval of the Earth's crust.

A most notable achievement was the imagination of a system of atmospheres with constituent vortex-particles whose motions are the source of various physical forces. Though some of the details, especially those concerning terrestrial magnetism, are now known to be erroneous, the general scheme has proved to be extraordinarily near the truth. Though certain details require modification to adapt them to recent discoveries, much of the theory can be shown to be in agreement with facts only recently determined, notably the theory of light given in the *Principia,* the theory that there are innumerable stellar galaxies scattered through space, that our Galaxy is magnetically controlled, etc. Some of these conjectures are so vaguely stated that one hesitates to identify them with modern ideas, but they are very suggestive and certainly are not far from the truth.

Finally, Swedenborg's anatomical researches, his discovery of the expansion and contraction of the brain, and the localization of certain functions in particular cerebral convolutions, his explanations of diverse physiological processes, novel even to-day, or at any rate until very recent times—all these features make the study of Swedenborg's science valuable for the elucidation of present-day science and indispensable for the explanation of some of his spiritual doctrines. Thus he is the first to note that there is a superspace in the spiritual world, and the first to connect the laws of that superspace with what we now call the "fourth dimension." He first recognizes that there is an influx into nature from the Spiritual world and announces that sustentation is perpetual creation; and it is shown to him that creation is instantaneous in the spiritual world, but is continued through generation in nature.

Are we then to regard Swedenborg's scientific writings as a final system of natural truth? Certainly not. Natural science is never final. Science must always be free to grow and to improve. New discoveries are continually being made in science. Previous announcements of scientific theory have to be modified and enlarged to include the new facts, and this change must go on perpetually. It is one of the signs that science is a live thing. Science is the great expositor of the New Age, and eagerly accepts the message of the Lord: "Behold, I make all things new." That is its charter of progress. Swedenborg himself was fully imbued with the scientific spirit.

Consequently, it would not be useful to study Swedenborg's science without, at the same time, comparing it with the re-statements and extensions of the present time. The result of my critical examination of the *Principia* was that "As a single consistent theory of creation, the *'Principia'* is not entirely successful. Its value is rather as an example of high thinking and as a mine of useful suggestions. Moreover, as Swedenborg learned later, creation is from the Spiritual Sun and can not be comprehended from merely natural experience. Nor are the laws of nature to be found by deductive reasoning, for the palimpsest of nature has many erasures."

What, then, is the chief end in our study of Swedenborg's science? I think it should be to become imbued with his spirit and method; to get his point of view which rejects neither the Baconian nor the Aristotelian method, but unites them in a combined attack on the unknown from within and from without. "At this day we are made wise only by means of experience," he says. But "he who has knowledge, and is merely skilled in experiment, has taken only the first step to wisdom; for he only knows what is posterior, and is ignorant of what is prior; thus his wisdom does not extend beyond the organs of the senses and is unconnected with reason. He who desires to be wise is wise from both." (*Principia.*)

Great deeds can be accomplished under the leadership of this many-sided man. Let us try to acquire the art from him.

I will cite a quotation from my paper on Swedenborg's *Principia*:

> Swedenborg's method has been called peculiar. It is, indeed, a new departure in science; but the method originated in a greater than Swedenborg. "Seek ye first the kingdom of God . . . and all these things shall be added unto you," says the voice of Jesus. It was new in science to begin with the acknowledgment of God, and from this as a center to deduce the principles of natural science. Henceforth religion and science are to be one. The conflict of the ages is ended.

The scientific writings of Swedenborg are like a great sea over which we may sail to many lands. But before the waters of that sea can be safely navigated, its rocks and shoals must be charted in order that the navigator may avoid them. If anyone says: I am not interested in destructive criticism. Show us something constructive. I reply that it is necessary to remove obstacles before the work of construction can begin. The elimination of error is therefore a fundamental constructive work.

Much of my scientific work in the past has been undertaken with a view to the testing of some of Swedenborg's conclusions and also to supplement them by supplying missing links. To save space and avoid repetition I shall occasionally refer to these scientific papers. I have also appealed to the scientific evidence presented by my contemporaries wherever it seemed available. As time passes, much of this work will doubtless have to be recast. Swedenborg's theories are not final, nor can ours be; but it is a duty we owe to him and to ourselves to try to perfect this admirable scheme of scientific truth. We see him sometimes searching for an idea which is just beyond his grasp and for which some of the necessary facts were then lacking; but all the time he was being Divinely led toward the truth. Today we can supply the missing facts in large measure and thus correct and complete the first imperfect conceptions. The time seems propitious for doing so, because the firm establishment of the doctrine of energy (his "conatus"); that of "heat as a mode of motion" to use Tyndall's phrase (not peculiar to Swedenborg either, in its essential conception, since *this* doctrine was also held by Newton, though abandoned by most of his contemporaries); the conception of light as made up of discrete centers of radiant energy, the modern "light-quanta" (not to be confounded with Newton's solid "light-corpuscles," but apparently agreeing with Swedenborg's particles of vibrating ether which have also a vague affiliation with electricity, and in their oscillatory electro-magnetic fields actually demand a surrounding continuous medium, which is Swedenborg's "aura"); the discovery that electricity is made up of discrete particles (which discovery is a striking confirmation of Swedenborg's doctrine of elementary particles); the discovery that the decomposition of radium is attended by the

mission of electrons and free helium atoms flung off at
normous speeds (confirming the truth of Swedenborg's idea
hat there are composite particles with contents in vigorous
nternal motion) ; the establishment of his hypothesis that
here are in iron least material particles which are magnets
vith their axes pointing in every direction and neutralizing
ach other, but which can be turned into parallelism by
troking with a magnet, when their separate magnetic ener-
ies reënforce each other; establishment by the X-ray exam-
nation of Swedenborg's general hypothesis of different sorts
f piling of spherical particles (atomic piling and lattice
tructure) in crystals; verification of his hypothesis that
here are numerous galaxies of stars; of his theory of the
rigin of "new stars" and of the "solar system"; together
vith hints that several other of his conceptions are just on
he verge of confirmation, to say nothing of his remarkable
ontributions to anatomy and physiology, some of which
vere confirmed or re "discovered" by others many years
fter, while some are not yet definitely accepted but are
n a fair way to follow the rest of the list of his extraordin-
ry previsions; and finally by no means omitting those lumin-
us explications of psychical phenomena, for which he will
e for all time the Divinely appointed scientific witness,
hings long scoffed at and rejected, but destined to mark a
evolution in human thought;—all of these things make
his an appropriate time for the presentation of a revised
ersion of Swedenborg's theories with adaptations to the
resent state of science. There never will be a time when
larger number of confirmations of the *essentials* of Swed-
nborg's scientific theories will stand ready to hand. But
nterpretation and correlation of his terms with those of
nodern science are necessary. In a sense, of course, this
vill *not* be exactly or literally what Swedenborg taught nor

would it be easy to give this since he frequently modified his ideas, as those who are engaged in original work are apt to do. The stickler for historical precision may object to this, but nevertheless to *interpret* seems to me the only sensible thing to do. Here we have a case of wonderful prevision of splendid truths, but marred by imperfections, mistakes and fallacies, which can easily be pointed out and corrected. But if people will insist on taking the scientific writings just as they stand, if people will have all or none, then the whole will go into the discard for lack of a little kindly criticism and legitimate interpretation.

Let no one claim that Swedenborg forestalled modern science—he did not forestall, but adumbrated it and supplied a skeleton scheme which only needs to be filled in and modified a little, in order to stand forth a genuine living doctrine, suggestive, prophetic!

Of things which must be thrown away from the scheme may be enumerated the Cartesian planetary vortices, the successive repetition of what is virtually the same structure in different orders of particles, whereas there is nowhere a precise repetition, the hypothesis of the crushing of the water particles in the depths of the sea to form salts, the theory of the origin of *terrestrial* magnetism and its variations, the hypothesis that elevated marine beds are due to higher tides in the earlier ages, hypotheses as to the nature and cause of color, and a few others.

In quoting from the theological works, the translations of the Rotch edition or of J. F. Potts are usually given; but I have had the privilege of comparing them in many cases with the original edition which was seen through the press by Swedenborg himself and certain slight emendations have been made thereby. I have sought aid from many sources

If any one deserves mention more than another, I would refer gratefully to the indispensable "Swedenborg Concordance" of Rev. John Faulkner Potts, which renders available a wealth of information concerning the theological works of Emanuel Swedenborg and incidentally throws much light upon his scientific teachings.

CHAPTER I.

CREATION BY INFLUX

Swedenborg's science, like all other genuine knowledge is founded on experience; but inasmuch as this experience "in both worlds" transcended that of any other man, and embraced both cause and effect, his wisdom is extraordinarily profound. Yet this does not mean that his science is infallible, that it is not capable of improvement, or that it should not be examined critically on its merits. The examination which we propose to make, after brief statements of our author's principal scientific doctrines, will consist chiefly in comparing them with the new knowledges which nearly two centuries of assiduous scientific research have accumulated. Much confirmation will be found, especially in the very recent advances in such natural sciences as physics, crystallography, metallurgy, geology, astronomy, anatomy and physiology. Moreover, a beginning is even now being made through psychical research in a confirmation of a few of his wonderful revelations concerning the world of spirit: its *super*space,* far exceeding the possibilities of tridimensional space; its law of correspondence, eminently confirmed by the phenomena of the dream-life; the discrete degree which separates the world of spirit from the world of nature, and yet the essential, most intimate consociation of the two through perpetual *Influx of Creative Energy* which is now seen to be indestructible (that is, the natural energy which is the outcome of this Influx;

* This term has been introduced by the writer to distinguish Swedenborg's conception of a discrete degree of extension in the spiritual world. The need of this distinction is shown in the New-Church Review for April, 1919, pages 265-6.

has all of the characteristics of an immediate derivative from the Divine Omnipotency; the doctrine of the *limbus*,* or organized human substance, separable from the gross body, and in a sense intermediate between it and the spiritual body, constituting an organized essence capable of being transferred and transmitted by paper and other relics,—these newer acquisitions of psychical science, though conducted as yet on a very limited scale, sufficiently verify the reality of Swedenborg's experience as that of the most remarkable clairvoyant and psychic of whom we have any record.

Swedenborg's science is peculiar in that it penetrates to the region of beginnings in the least and invisible parts of nature, affirms that the air particle is not (as had been previously supposed) a structureless atom, but that it contains a complex structure in three degrees—particle within particle, each a system of moving forms and forces perpetually changing and continually receiving the only indestructible thing in nature, which is spiritual inflowing "*conatus*," or energy from an inexhaustible spiritual source.

It takes as much energy to sustain nature as it ever did to produce it. Sustentation is perpetual creation, according to Swedenborg. In a more limited sense so-called "creation" of living forms is said to be maintained by *generation*. This statement, this vision of the universality of something akin to the marriage relation throughout all nature and of the peculiar nearness of approach to the Infinite in all that relates to causation and the production of new individual forms,—the microcosm imaging the macrocosm,—all of this profound insight into the mode of creation bears witness to Swedenborg's grasp upon a fuller and truer doctrine of evolution than has yet been received by the world of science. As yet the would-be expounders of evolutionary theories have been contented to dwell in appearances, and have not ventured to dig far beneath the surface of things. Progress has no doubt been made; but a redistribution of effort and a rediscussion of facts are imperatively needed. On the one hand Swedenborg's imperfect natural science must be supplemented by later discoveries; but on the other hand a blindly groping natural science must be invigorated and given a new lease of life by reception of Swedenborg's vast stores of spiritual experience. In the light of these disclosures (at present almost wholly ignored, though the most important the world of science has ever known), the fact of creation through generation assumes new significance. We are taught that new forms of life in infinite variety exist already in the spiritual world ready for incarnation, awaiting only a receptive vessel and opportunity to inflow. Here the doctrine of variation by fluctuation and mutation receives a rational explanation. Perpetual variation and mutation from Influx of the Infinite lead to reception under favorable circumstances: (*a*) by selection, whether natural or artificial; (*b*) through sexual selection; (*c*) by use, since the objections of Weismann on the score of nonheredity have never been able to explain away testimony adduced by Lamarck, Cope and others, of at least a long-range heredity of acquired forms and functions, even though minute details of form acquired by individuals through use may not be immediately transmitted to their descendants,—while Reichard's hypothesis of a dual germ-plasm offers a way out from the dilemma;* also (*d*) by sheer usefulness, as in Darwin's data on the intercourse between insects and plants whereby both are improved and benefited, while insects and flowers are evolved *pari passu;* and (*e*) by mutual aid through a more direct helpfulness whereby community-action is evolved, thenceforth determining the course of numerous beneficent alterations and adaptations of modes of life and of physical forms of which there are many degrees ending in the marvels of the beehive.§ All of these factors may be involved in evolution, and yet in no sense are they incompatible with *Creation by Divine Influx* through receptive forms. Contrary to a much prevailing prejudice, evolution of life-forms through modifications imparted by means of the generative process involves no necessary denial of Creative work under the leadership of a Divine Providence. In fact without such universal providing of the *means* for selection,—whether by variation or by the seeming accidents of environment,—improvement of life-forms could not proceed. Creation is both a spiritual and a natural process; and only those who refuse to open their eyes to more than one side of the case, find any incompatibility in the two.

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* For recent confirmations of the reality of what Swedenborg called "the limbus," or a human organized form and force consisting of the purest and finest substances of nature, but separable from the gross body—confirmations which are remarkable, even though confined at present to generalities—see an article by J. D. Beresford entitled, "A New Form of Matter," in Harper's Magazine for May, 1919, pages 803 to 816.

Swedenborg's great doctrine of creation through *two* suns could not be announced until he had obtained experience in the spiritual world. We may therefore begin our study by a quotation from his *Angelic Wisdom concerning the Divine Love and the Divine Wisdom,*† nn. 153 to 156.

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* See the writer's article on Dr. Reichard's book in the New-Church Review for July, 1915, pages 420 to 433, and especially the argument pages 432 to 433.

§ Compare an article on "The Theory of Evolution" in the New-Church Review for October, 1917, pp. 568-591, in which especial attention is called to Kropotkin's notable book on "Mutual Aid."

† In quotations, this work is usually called by an abbreviated title: "Divine Love and Wisdom."

There are two Suns ‡ through which all things are created by the Lord, the Sun of the spiritual World and the Sun of the natural World. All things are created by the Lord through the Sun of the spiritual World, not through the Sun of the natural World, since the latter is far below the former; it is in middle distance; above it is the spiritual World, and below it is the natural World. This Sun of the natural World is created to render aid, as a kind of substitute; this aid will be spoken of in what follows [namely, that "the Sun of the natural World is pure fire, consequently dead; nature also is dead, because it derives its origin from that Sun . . . but the Sun of the spiritual World is living," n. 157].

The Universe and all things therof are created by the Lord, the Sun of the spiritual World serving as a medium, because that Sun is the first proceeding of Divine Love and Divine Wisdom, and from Divine Love and Divine Wisdom all things are. In every thing created, greatest as well as least, there are these three, End [or purpose], Cause [or means], and Effect [or the final actual thing which includes within itself the preceding formative degrees]. A created thing in which these three are not, is impossible [just as the plan and the instrumental materials have to be conjoined in the thing itself in any work of man]. In what is Greatest, that is, in the Universe, these Three exist n the following order: In the Sun, which is the First proceeding of Divine Love and Divine Wisdom, is the End of all things; in the spiritual World are the Causes of all things; in the natural World are the Effects of all things. How these three are in things First and Last shall be shown in what follows. Since, then, no created thing is possible in which these three are not, it follows that the Universe and all things thereof are created by the Lord through the Sun, wherein is the end [first end, purpose, or beginning] of all things.

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‡ The capitalization here is that of the original Latin edition and elsewhere, wherever it has been possible to consult this authority. Swedenborg lived at a time when styles were changing. Newton capitalizes all of his nouns, whether common or proper, as the Germans do to this day. Swedenborg in his scientific writings usually conforms to the newer fashion and omits to capitalize his common nouns. His practice in the theological works is peculiar. Sometimes a capital is employed with a noun, adjective, or verb, apparently to denote a mild form of emphasis, but not as strong as where italics are used, which they frequently are for whole sentences or even paragraphs. Sometimes, however, the capital is used to indicate a particular meaning. Thus, heaven with a small h means the heaven of stars, but Heaven spelled with a capital H means the Heaven of Angels; and in this direction a capital is very generally used to call attention to the fact that the word so treated is intended to convey an unusual, higher, or spiritual meaning which is sometimes explicitly defined, and in any case should put us on our guard. The modern translators are apt to suppress these capitals indiscriminately; but even if we think we know better than the author what he meant to say, the alteration is of questionable validity.

Creation itself cannot be brought within man's comprehension unless space and time are removed from thought; but if these are removed, it can be comprehended. Removing these if you can, or as much as you can, and keeping the mind in ideas abstracted from space and time, you will perceive that there is no difference between the maximum of space and the minimum of space [i. e., one is as difficult to grasp as the other, and in either the infinitely great or the infinitely small, we touch nfinity]; and then you cannot but have a similar idea of the Creation of the Universe as of the creation of the particulars therein; you will also perceive that diversity in created things springs from this, that there are Infinite things in God-Man, consequently things without limit in the Sun which is the first proceeding from Him; these countless things are presented as in an image, in the created Universe. From this it is that no one thing can anywhere be precisely like another. From this comes that variety of all things which is presented to sight—in the natural World together with space, but in the spiritual World with appearance of space; and it is a variety both of generals and of particulars.

The Creation of the Universe, and of all things thereof, cannot be said to have been wrought from space to space, or from time to time, thus progressively or successively, but from Eternity and from Infinity; not from Eternity of time, because there is no such thing, but from Eternity not of time for this is the same with the Divine; nor from Infinity of space, because again there s no such thing, but from Infinity not of space, which also is the

> same with the Divine. These things, I know, transcend the ideas of thoughts that are in natural light, but they do not transcend the ideas of thoughts that are in spiritual light, for in these there is nothing of space and time. Neither do they wholly transcend ideas that are in natural light; for when it is said that infinity of space is not possible, this is confirmed by every one from reason. It is the same with eternity, for this is infinity of time. If you say "to eternity" it is comprehensible from time; but "from eternity" is not comprehensible unless time is removed.

These things perhaps need further illustration. When it is recognized that creation of even a single specific living form with its numerous adaptations and a long list of properties of special substances which enter into its composition, a still longer list of cellular forms which enter into its structure and which have required for their inception previous ages of development and discipline through innumerable vicissitudes, also physical and chemical properties of matter which would clash and render orderly life impossible unless there had been infinite foresight of all possible interrelations of the underlying natural forces, to say nothing of the psychological factors which are too vast to be conceived by man, it is evident that such a creative work transcends space and time. To cite but a single example among myriads: We know that all living forms are dependent on water as an essential constituent of sap or of blood. Consider what would happen if the behavior of water were even only a little different from what it is. If the exceptional property by which water is a little lighter in its solid than in its liquid form, were to be abrogated, our ponds and rivers would be frozen solid. Even the summer's sun could not melt the great masses of accumulated ice, and a large part of the earth would become an arctic waste. By its absorbent power for certain radiations of great wave-length, the vapor of water in the atmosphere preserves the surface of the ground from sudden fluctuations of temperature and prevents destruction of vegetation by frost in summer. Were the chemical affinities of water to be somewhat more pronounced, all of the water of the globe might be locked up in combination with its solid core. A trifling variation in the surface tension of the water molecules along surfaces of contact, which is produced by dissolving a small amount of salt in the water, makes sea-water incapable of continuing to hold in suspension the fine sediments carried to the ocean by rivers. In consequence of this property, the sediments are precipitated along the continental margins, and the lands are kept from general dissipation in the oceanic depths from which, otherwise, only a few islands, the projecting summits of submerged volcanic peaks, would emerge. Considering that innumerable similar adaptations and harmonies exist throughout nature, it will be seen that this law of heavenly harmony and mutual adaptation is the supreme law, without which it would be impossible for a world to exist. This harmony is attributed by Swedenborg to a specially organized form,

> . . . the highest form of nature, or the perpetually vortical form, which is the same with the celestial form, in which almost all boundaries are, as it were, erased as so many imperfections, and still more perpetuities or infinities are put on; wherefore this form is the measure of the vortical form, consequently the exemplar or idea of all inferior forms, from which the inferior descend and derive birth as from their beginning, or from the form of forms. . . . From this form those faculties and virtues result, by virtue of which one thing regards another as itself, nor is there anything but what consults the general security and concord, for in that form there is not given any fixed center, but as many centers as there are points, so that all its determinations, taken together, exist from mere centers or representations of a center, by which means nothing can be respected as proper to it [i. e., proper to itself alone], unless it be of such a quality

> that from what is general, or from all the centers which taken together produce what is general, it may flow-in into itself as a similar center, and may reflow through an orb for the benefit of all, or into what is general (Worship and Love of God, n. 6, footnote).

When it is remembered that the above illustrations are but a few of myriads of correlated properties and procedures any one of which is indispensable to the continuance of life; when, for instance, it is known that the blood of present-day land animals contains mineral salts in definite proportions which are a relic of the composition of the sea water in Paleozoic ages at a time when the ancestors of these creatures were sea animals of a much lower order,—animals which took in the water of the sea as an essential means of growth and vital organization; when it is known that the composition of certain substances contained in the blood of animals exhibits minute but measurable differences which point out which animals are most closely related and which are farther apart, giving a further indication of the series of derivations by which evolution has been effected,*—it will be seen that numberless processes and ages of geologic history have gone to the development of even one of the amœboid corpuscles, which swim in the blood of a man as in their native sea, and yet have somehow a human quality. Granting that the ancestral amœba from which these are descended had a tiny soul of its own, that is, a spiritual essence derived from the world of causes, a minute fractional part of that human world to which it was eventually to return, possessed of a *raison d'être*, a motive, a plan and mode of life looking forward to ages of future development and use,—can we doubt that creation is beyond time and space, that it involves infinity even in least forms?

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* Cf. "The Theory of Evolution," in the New-Church Review for October, 1907, pages 574-5, where reference is made to researches by G. H. F. Nuttall, G. L. Graham-Smith and T. S. P. Strangeways.

"God will be gracious to us, and bless us;
He will cause his face to shine upon us. Selah!"
(Psalm lxvii, 1.)

It means that God will gift us with truth and bless us with good.

> By the Lord's causing his face to shine, is signified illumination by Divine Truth from Divine Love. For the Divine Truth which proceeds from the Lord as a Sun in the Angelic Heavens, is the source of all the light there, and also illuminates the minds of angels and fills them with wisdom. The face of the Lord, in the proper sense, is the Sun of the Angelic Heaven, for the Lord appears to the Angels of the interior Heavens as a Sun, and this from His Divine Love; for Love in the Heavens, when it is presented before the eyes, appears as fire, but the Divine Love as a Sun; from that Sun proceed both heat and light, and the Heat is Divine good, and the Light is Divine truth. (Apocalypse Explained, n. 412.)

The beginning and end of creation is man. Can the wisdom which formed the universe be less than human? Is it not evidently more than human, infinitely more, even the Wisdom of God-Man? Let us hear what our teacher has to say:

> By the Ancients man was called a Microcosm, from his representing the Macrocosm, that is, the Universe in its whole complex; but it is not known at the present day why man was so called by the Ancients, for no more of the Universe or Macrocosm is manifest in him than that he derives nourishment and bodily life from its animal and vegetable Kingdoms, and that he is kept in a living condition by its heat, sees by its light, and hears and breathes by its atmospheres. Yet these things do not make man a microcosm, as the universe with all things

thereof is a Macrocosm. The Ancients called Man a Microcosm, or little Universe, from truth which they derived from the knowledge of correspondence, in which the most ancient peoples were, and from their communication with angels of Heaven; for Angels of Heaven know from the things which they see about them that all things of the universe, viewed as to uses, represent man in an image.

But the truth that man is a Microcosm, or little Universe, because the created universe as to uses is, in image, Man, cannot come into the thought and from that into the knowledge of any one on earth [unless] from the idea of the Universe as seen in the spiritual World; consequently, it can be corroborated only by an Angel who is in the spiritual World, or by some one to whom it has been granted to be in that World, and to see the things which are there. As this has been granted to me, I am able, from what I have seen there, to disclose this arcanum.

It should be known that the spiritual World is, in external appearance, wholly like the natural World. Lands, mountains, hills, valleys, plains, fields, lakes, rivers, springs of water are to be seen there, as in the natural World; thus all things belonging to the mineral Kingdom. Paradises, gardens, groves, woods, and in them trees and shrubs of all kinds bearing fruit and seeds; also plants, flowers, herbs, and grasses are to be seen there; thus all things pertaining to the vegetable Kingdom. There are also to be seen there, beasts, birds, and fishes of every kind; thus all things pertaining to the animal Kingdom. Man is there as Angel or Spirit. This is premised that it may be known that the universe of the spiritual World is wholly like the universe of the natural World, with this difference only, that things in the spiritual world are not fixed and settled like those in the natural World, because in the spiritual world nothing is natural, but everything is spiritual.

That the universe of that World represents man in an image can be clearly seen from this, that all things just mentioned appear to the life and have existence about the angel, and about the angelic societies, as if produced or created from them; they are about them permanently, and do not pass away. That they are as if produced or created from them is seen by their no longer appearing when the angel goes away, or when the society passes to another place; also when other Angels come in place of these the appearance of all things about them is changed—in the parks the trees and fruits are changed, in the flower gardens the flowers and seeds, in the fields the herbs and grasses, also the kinds of animals and birds are changed. Such things have existence and are changed in this manner, because all these things come into existence according to the affections and consequent thoughts of the angels, for they are correspondences; and because things that correspond make one with that to which they correspond, they are an image representative of it. This image is not seen when these things are viewed in respect to their forms, it is seen only when they are viewed in respect to uses. It has been granted me to perceive that Angels, when their eyes were opened by the Lord, and they saw these things from the correspondence of uses, recognized and saw themselves in them.

Inasmuch as these things which have existence about the angels, corresponding to their affections and thoughts, represent a Universe, in that they are lands, plants, and animals, and these constitute an image representative of the angel, it is evident why the Ancients called man a microcosm. (Divine Love and Wisdom, nn. 319 to 323.)

From the Sun of the spiritual world proceed atmospheres in three degrees, formed out of love and wisdom, for love is veritable spiritual substance and wisdom is its form. Out of these spiritual-substances all of the objects which appear to the spiritual senses in the spiritual world are woven, according to the lives of its inhabitants—beautiful if those lives are kind and loving, direful if hatreds and malignities are harbored.

Though the spiritual and natural worlds are not continuous, but are conjoined through correspondences, the spiritual world being in superspace, but the natural world in natural space which is separated from the former by a discrete degree (of which more anon), yet there are certain resemblances, along with the differences. The spiritual world originates from a single spiritual Sun; but the natural worlds from innumerable suns composed of natural substances formed out of a universal magnetic aura which is the first of nature. Space is filled with a universal atmosphere whose closely juxtaposed particles are indestructible and originate by perpetual influx of "*conatus,*" or energy from an infinite spiritual source, resting at last upon the spiritual Sun.

Starting from central points, perpetual motions outward from one of these point-sources moving in spiral trajectories along some such path as the sinusoid spiral, $r = a \sin (b\,\theta)$,[*] where positive and negative branches are equal and the limit is a circle of definite radius, generate by multiplicity of spirals a spherical surface which defines a primal particle; and from the secondary motions of these particles among themselves are formed vortical composite particles, said to be of two orders and called "elementary" by Swedenborg, but which we should now speak of as electrons and atoms. Thus there are three orders of particles in the series which makes matter:—primal particles, electrons, and atoms. The atoms are now known to be approximately 10^{-8} cm. in diameter. The electrons are about one one-hundred-thousandth as large (1.9×10^{-13} cm.).[†] We do not know the size of the primal particles but they are undoubtedly excessively minute in respect to an electron. If we may hazard a guess that the same ratio is continued to the third order, the primal particles should have a diameter of about 10^{-18} cm. (one million-million-millionth of a centimeter). Swedenborg's first guess was that the ratio of the dimensions of successive orders might be 30 : 1. Subsequently he saw that it was probably much larger:

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[*] See the writer's notes to the new English edition of Swedenborg's Principia, page 618.

[†] See Millikan's treatise on "The Electron."

> The third active consists of 1,000,000 points, or 10,000 first substantials, and so on. This number I have fixed upon only by way of example; for we cannot tell what may be the number which at first has to be multiplied into itself. (Principia, Part I, Chapter VII, "Actives of the Third Finite," n. 1.)

Swedenborg's conception of an elementary vortical particle is a most remarkable prevision, for it now develops from current knowledge of the properties of the electron that there is a reason why this particle should have that particular shape and structure and no other. Lord Kelvin's "vortex-atom," conceived as formed out of a universal fluid medium by motion after the plan of a smoke-ring in air, has not been successful. The difficulties in this direction seem to be insuperable. Swedenborg's particle evades these difficulties. Nevertheless, his idea requires some modifications. He supposes that the elementary particle is both elastic and also expansile and contractile through a wide range. We may grant elasticity to this form, but it is specifically that of an encompassing little atmosphere of ether which pertains to that particular corpuscle; for the electrons themselves never come into contact except through their atmospheres. These electronic atmospheres, like the atmosphere of the earth, are densest at the periphery of the electron (in fact, so dense that two electrons cannot be forced into contact) but the density rapidly diminishes outwardly. The sheath follows every motion of the enclosed particle, but when stripped off by some violent shock, the sheath is, as it were, turned inside out; the greatest density is at the periphery of what is now a free ether particle and the original rotary motion is transformed into a rectilinear motion of propagation with a residual rocking motion and a trifle of pulsation as a relic of the special motions of the originating electron.*

In examining the trajectories of β-rays, or of secondary cathode rays started by the X-rays, Compton and Shimizu † have been struck by this: That these trajectories terminate usually in helices. On the stereoscopic plates taken by C. T. R. Wilson the helices are both dextrorse and sinistrorse and therefore do not stand for a magnetic field within the matter. Consequently, Compton proposes the hypothesis that the electron itself is in rapid rotation and this is equivalent to a little magnet. The magnetic field induced in the surrounding medium reacts to incurve the trajectory. There may also be the action of external forces upon the gyroscope formed by the electron. These phenomena are entirely in accord with what might be surmised if the electron is formed on the pattern of Swedenborg's first elementary particle.

I have spoken of pulsation, for the electron, in addition to its motion of vortical rotation, also expands and contracts with a rhythmic pulsatory motion on which gravitation depends, but through a range which is relatively small, so that the dimension of an electron is practically a fixed quantity. The existence of pulsatory motion was foreseen by Swedenborg, but he did not assign it to any definite point in his series, nor was he aware of its connection with gravitation.

The electron is also (as Swedenborg supposed his elementary particles to be) *exceedingly active within,* and presses back the surrounding universal atmosphere, condensing it to a limit (or "finite," to use Swedenborg's term) by the centrifugal force of its rapid rotation (whose velocity at the boundary is equal to that of light), and this condensed envelope of aura, structured by motion, is the ether, its particles originated by the electrons, sharing their motions in certain respects and having somewhat the same dimensions though a different structure; but as far as we can see, the particles of the universal medium at the boundary of the electron, though finiting in function by virtue of their strong pressure-gradient, do not differ in form or constitution from those that are within the boundary save as to speed. As Swedenborg's language is rather vague, and the mathematics not entirely free from mistakes (which, however, can be easily rectified), it seems entirely permissible to make his conception a little more definite, which can be done without altering anything that is essential. Only the most general description of the vortical particle which Swedenborg imagined is needed here and this may be gathered from the following quotations:

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* Cf. the writer's paper on "The Luminiferous Ether"—Occasional Scientific Papers of the Westwood Astrophysical Observatory. Number 2. Boston: The Four Seas Co., 1919. Previously printed in the New-Church Review for October, 1918.

† Philosophical Magazine, Vol. XLI, pages 279-281, 1921.

> It is motion only which can give figure and space; without motion nothing could flow together into a bounded aggregate. The cause of anything being bounded is motion alone. It is motion therefore which distinguishes, bounds, gives figure, makes one thing equal to another, retains it within its limits, and so holds it together that it can subsist as one finite capable of being separated from another. (Principia, Part I, Chap. IV, n. 6.)
>
> Perpetual circulation is like a perpetual spiral, winding, as it were, from the center to the periphery, and again from the periphery to the center; thus it is a flowing spiral motion continually returning upon itself.
>
> This motion must have its center in effort, and it must have a periphery. (Principia, Part I, Chap. II, n. 21.)
>
> The particles in a finite or compound are similar to one another, in regard to form, arrangement, and motion; the individual

> parts of these again are also similar, and so on up to the first point in which lies the primitive force and first cause of finiting the sequents. (Principia, Part I, Chap. VI, Section "On the Form, Arrangement and Motion of Parts," n. 1.)
>
> The arrangement of these similar entities is obtained by motion, and the form both of the motion and arrangement is spiral. . . . Poles also and polar cones are necessarily produced by the spiral form. With regard, however, to these spires or spiral circles [circulations], I observe, that the spires nearest the center have a greater curvature, and those farther off a less, both in the polar cones and in the surfaces [interior layers]; also that in the polar cones the kind of spire is different from what it is in the surfaces. . . . A finite which is an aggregate or assemblage of parts reduced by motion to a certain arrangement does not consist of one surface, layer, and row extending from the center to the outermost surface, but it consists of several; . . . it has a convex form, but at its two opposite ends it has poles gradually widening from the center, and hollowed out into the form of two cones. (Ibid., n. 2.)
>
> In elementary particles the center of gravity is in the surface; particularly during a state of compression when the surface is, as it were, convoluted into several folds. (Ibid., n. 8.)

This sentence is unintelligible, save as a statement that resistance is concentrated in the superficial layers of the particle; because the averred reason, namely, that a component stream of constituent consecutive particles following one another in a spiral figure, has its center of gravity (if the particles are equal and equably distributed along the spiral) not exactly at the center but at a little distance from the center, does not apply to a complex consisting of innumerable spires, since the center of gravity of the complex is by symmetry at the center of figure. The passage just quoted also rules out the supposition that a *single* "row" is meant.

Moreover, an exceedingly obscure argument for a polar conjunction of particles (in n. 8) rests on this supposed eccentricity of centers of gravity. But a true explanation is given earlier in the chapter (n. 33 of the 1st section), where it is said that "these elementary particles cannot be in contact, except in a manner accordant with the motion of their surface and their figure." This is entirely satisfactory. We can easily see that in order that electric particles may attract one another, it is necessary that the motions in their juxtaposed surfaces be congruous. Nothing else is necessary. The similarity of figure and dimensions supplies all other needs. These attractions were fully elucidated by Ampère's experiments on the mutual action of electric currents.

A further explanation (*Ibid.*, Part I, Chap. vi, n. 20) of the origin of the polar cones is far from convincing. The primal particles have been described in an earlier number as spherical and as having a bubble-like form. But it is said that re-entering cones are developed in these through pressure: "In a state of compression the elementary particle begins to form certain polar cones toward the center. In proportion to the degree of compression it becomes more and more like some finite in which the points or particles flow from the center to the circumference, through the poles toward the center, and so on always reciprocally." This argument assumes that the subsidiary particles (finites) forming the surface of the elementary particle cannot be compressed, and must betake themselves to the interior of the elementary when it is compressed. One would sooner expect the incompressible shell to be broken (like an egg-shell) by pressure.

Apart from minor objections to a few unnecessary details and to some infelicities of description which I have removed in my notes appended to the new English edition of the *Principia*, where will be found emended figures of the supposed primal and elementary motions, the conception, when slightly revised, has much in it which is of interest, and at once gives a *raison d'être* for some of the properties of the electron, whereby it becomes very probable that this particle is no other than the "atom" of electricity which has now been isolated and measured, and has been shown to be the sole constituent substance out of which the chemical atoms are formed.*

Swedenborg predicated two orders of vortical particles, and we may presume that the atoms of the chemical elements are also vortices; but, if so, they are complex vortices of another sort from the electrons, since the thermal properties of the elements and the existence of inner supernumerary electrons arranged in tiers on a cubical pattern, require that there shall be *concentric* spherical shells of revolving electrons dividing the interior of the atom into numerous chambers. In a sense, this plan of the atom (for which see Chap. IV.) which can be shown to be essential to Langmuir's theory of the arrangement of those specially assorted electrons within the atom which make up the "Moseley number," may be considered as an adaptation or modification of one stage in Swedenborg's "Bullular Hypothesis." This hypothesis affirms the existence of a series of bubble-like particles. We may provisionally accept the existence of three orders of such spherical particles, namely: (1) the *primal particles* (or "substantials," as Swedenborg calls them) of the aura of the universe which fills all space; (2) the *particles of the ether*, which are most intimately associated with the electrons, each electron being surrounded by its own individual ethereal atmosphere, but which very likely can also exist separately in a more attenuated form as a general ethereal atmosphere, surrounding the atoms, accompanying them wherever they go, interpenetrating the atomic structures whether solid, liquid, or gaseous, and therefore accompanying the earth as a second atmosphere far more rare than the aerial one, and very likely the vehicle of telepathic communication, while its free radiant form is the light particle and the vehicle of every kind of radiant vibration from the wave of the wireless telegraph to the X-rays; (3) the *atoms* which form the gross atmosphere and all material substances—not bullular in the sense of having a bounding pellicle of continuous substance, but less rigidly defined by spherical shells of rather widely separated electrons. All of these forms are continuously and successively created by a perpetual Influx of Divine Creative Power whose ultimate is energy.

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* Compare my theory of the chemical atom, founded on Swedenborg's theory of particles structured by motion (though with modifications required by recent discoveries), in the aforesaid paper on "The Luminiferous Ether." For the "recent discoveries" a long list of papers in the London, Edinburgh and Dublin Philosophical Magazine and other journals must be consulted.

The spherical and bullular ether particle, previously existing as an electronic sheath, when violently thrown off from the electron at the moment of the latter's gyrostatic uptilting, speeds through space with the velocity of light and conveys radiant and luminous vibratory impulses imaging those of the electron. Swedenborg affirmed that light consists of particles, and that these discrete particles vibrate,—a view which harmonizes with Planck's doctrine of light-quanta, but is more explicit. He attributed the fluidity of water to its permeability by interfluent ether. But "when there is no motion between the ether particles, the aqueous particles coalesce into a certain hard and material mass, from which they cannot be liberated except when the ether is urged into motion and a state of rigidity." Interatomic radiation has been found to be most intimately associated with the gaseous state.* The need of it in the liquid state has not yet been recognized. Our author's speculations concerning the form of a water particle have no longer any interest, because chemistry had not then been born. Still in his conception of a special virtue in certain groupings of particles arranged in several modes of piling, there resides the germ of the modern science of stereochemistry.

The primal particles of the universal atmosphere, which serve for the reception and inflowing of the most subtle forces of nature, when acted upon by electronic circuits, convey magnetic impulses, and are thereby set in special rotary motion and arranged in vortex-filaments. Swedenborg's picture of a helical vortex-filament threading the pores of a particle of iron,—"an effluvium," as he thinks, emitted by the iron to form a sort of excessively rarified metallic atmosphere,—may be compared with what Faraday named a "magnetic line of force." The two are not dissimilar; but the metallic effluvium has never been demonstrated and seems unnecessary. The penetrative power of the magnetic force is best explained as arising from an impalpable atmosphere whose particles are so fine that they pass with scarcely any resistance through the relatively coarse network of matter. The slight differences in magnetic permeability for different materials are sufficiently explained as the result of a transferring of a part of the energy of vortical spin in the aura to the interior structures within the atoms. If it were necessary that metallic effluvia of iron should accompany the magnetic flux, it would not be possible for the magnetism of the earth's iron core to penetrate the deep layers of superficial stony material. Influx is almost immediate, into the inmosts of nature, but becomes more and more hampered on reaching the coarser structures and outer coverings.

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* As shown in my papers: "On the Solar Constant," Am. J. Sci., Ser. 4, Vol. XXXIX, pages 206-7, Feb., 1915; and "The Radiant Properties of the Earth from the Standpoint of Atmospheric Thermodynamics," Occasional Scientific Papers of the Westwood Astrophysical Observatory. No. 3, pages 55-6. Boston: The Four Seas Co., 1920. The important point is this: The aerial particles cannot fulfill their function as components of the lowest degree of atmosphere, cannot fulfill the law which governs the distribution of density and its variation with the altitude, unless surrounded by and interpenetrated by an ethereal atmosphere which conveys the radiant impulses of the particles and keeps them in equilibrium. Thus is fulfilled Swedenborg's statement that the air particles are surrounded by ether and are kept in form and function by the pressure of the ether. What is this ethereal pressure? Not a gaseous pressure, for that is not the function of the ether, but a radiant pressure which is sui generis. There is not room here for an elaborate explanation and I must refer, in this as in some other cases, to my collateral writings.

Though the particles of the aura may be thrown magnetically into a vortical spin, we are unable to acquiesce in the opinion that the individual particles are themselves cored vortices of the same sort as the subsequent elementary particles. This will be discussed in another chapter. The electrons, however, are of this description, and their revolutions within the atom,—which constitute the atom, harmonize well with what Swedenborg may have meant when he spoke of

> The second or magnetic element of the world; that is, the next elementary particle composed of third finites and of the actives of the second and first finite [primal atomic elementary particles composed of the first or universal atmosphere in which magnetism resides, and of revolving electrons formed therefrom by motion]. This element, together with the former, constitutes the solar vortex, and is the one which principally contributes to the phenomena of the magnet. (Principia, Part I, Chap. IX. Heading.)

We know that the outer layers of the sun consist of free atoms. But there is much evidence that in the sun's deeper layers some of these atoms are resolved into more elementary forms,—the proto-elements of Lockyer; and it is conceivable that in the deepest layers, where the heat and pressure are enormous, this resolution reaches to the electronic components of the atom. At any rate we know that when the sun is hottest at the period of maximum sunspots, immense numbers of electrons are shot off from the sun, some of which enter our earth's atmosphere and produce the aurora and magnetic storms. Swedenborg's statement as to the constitution of the sun (affirming the presence of both second and first elements, atoms *and* electrons) cannot lightly be set aside, although it requires some modification, as we shall see. At any rate we are certain that the sun's outer layers are atomic.

As to the second part of the above statement in respect to the magnet, we now know that a revolving electron is an elementary magnet. This justifies the identification of the "second elementary particle" with the atom which consists of revolving electrons. But it is not probable that the vortical form duplicates that of the electron.

The subject of atmospheres in series leads us to Swedenborg's very important and unique doctrine of discrete and continuous degrees. It has long been known that the aerial atmosphere continually diminishes in density as we ascend, and the inference has been drawn that this atmosphere has a limit at no great height above the earth's surface—at most a few hundred kilometers. We are also led to infer that there are gradations in the density of the ethereal atmosphere, because the phenomena of refraction imply a greater density of the ether in the interior of denser refracting substances, and a smaller ethereal density where the gravid matter is rare.

The universal aura is the most equably distributed thing in nature, but in addition to its structural diversities out of which matter arises, there begins to appear evidence of vast currents in the aura which bear on their bosom not mere clouds of fine particles, but suns and systems of stars. In the spiral nebulæ there are streams of stars which issue from centers of brilliant condensation and proceed outward on spiral paths. The suggestion is that these streams are due to a general motion of the sustaining aura, for if the stars are formed out of the aura, they must share whatever general motion it possesses. These facts were unknown in Swedenborg's time, yet he foresaw them and believed that the stars are moving in *magnetic* (i. e., spiral) courses.

Other facts support the supposition that there are streams of enormous size in the aura. Mr. Harlow Shapley finds that the globular clusters are not distributed indiscriminately, but that they are aggregated in certain regions of space, which strongly suggests that these stellar groups form a family and are borne along by specially defined aural currents. Such currents will obviously pass by continuous degrees into currents of a different trend coming from other parts of the universe; and the distinction will be purely one of local motion, and will be no greater than that which separates the waters of the Gulf Stream from neighboring bodies of sea water and from diverse other oceanic currents.*

But the distinction between the aura and the ether, or between ether and air, is more fundamental. It involves a difference of function, and a total dissimilarity of the general form of motion in the least parts of which the media consist, even if there may be a few resemblances in minor details, such as a tendency of elementary particles of different orders to take a nearly spherical form, and even, as

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* Cf. Chapter VI, Section E.

Swedenborg supposed, a bubble-like form. Yet we cannot accept Swedenborg's suggestion that the *same* form of motion is repeated in particles of different orders, with no change save in the scale of magnitude. We speak, however, subject to correction whenever sufficient experimental knowledge shall have been obtained to test these suppositions further. At present these structural conceptions lie on the utmost verge of the scientific horizon. Present-day science is here still in the speculative stage, nor does it appear to be aware that it has much to learn from Swedenborg. This is especially true in regard to structured particles. Nearly every one has heard of Lord Kelvin's hypothesis of a vortex-atom, but few are aware that Swedenborg had proposed a vortex-particle which is a decided improvement on Lord Kelvin's.

CHAPTER II.

THE THREE ATMOSPHERES OF THE NATURAL WORLD

IN order to see the nature and connection of the three natural atmospheres, and why there are *three*, no more and no less, something must be known about discrete and continuous degrees. I therefore begin by quoting what Swedenborg says in *Divine Love and Wisdom*, n. 184:

> A knowledge of degrees is like a key to lay open the causes of things, and to give entrance into them. Without this knowledge, scarcely anything of cause can be known; for without it, the objects and subjects of both Worlds seem perfectly simple, as though there were nothing in them beyond that which meets the eye; when yet compared to the things which lie hidden within, what is thus seen is as one to thousands, yea, to tens of thousands. The interiors which are not open to view can in no way be discovered except through a knowledge of degrees. For things exterior advance to things interior, and through these to things inmost by means of degrees; not by continuous but discrete degrees. "Continuous degrees" is a term applied to the gradual lessenings or decreasings from grosser to finer, or from denser to rarer; or rather to growths and increasings from finer to grosser, or from rarer to denser; precisely like the gradations of light to shade or of heat to cold. But discrete Degrees are entirely different; they are like things prior, subsequent, and final; or like end, cause, and effect. These degrees are called discrete, because the prior is by itself; the subsequent by itself; and the final by itself; yet taken together they make one. There are Atmospheres from highest to lowest, that is, from the Sun to the earth, called ethers and airs, that are separated into such degrees; they are like simples, collections of simples, and again collections of these, which taken together are called a composite. Such Degrees are discrete, because each has a distinct existence,

> and these degrees are what are meant by "Degrees of height"; but the former Degrees are continuous, because they increase continuously, and these degrees are what are meant by "Degrees of breadth."

Because God is triune, everything that proceeds from Him is in trinal order. The natural world subsists by a perpetual flow of energy from a spiritual source through three degrees of nature to the lowest, which necessarily includes intermediate and highest degrees. The supreme atmosphere of nature is that which Swedenborg, in *The Economy of the Soul's Kingdom,* (n. 312) calls the aura. "Between the first aura and the air there is this difference, that the former involves active force alone, while the latter besides has the adjunct of gravity." The aura fills all space and may, indeed, be said to *produce* space. The aura is incompressible, save to a very slight extent at the surface of the electrons where its pressure increases suddenly to overcome the centrifugal force produced by the extraordinarily rapid electronic spin. In a special sense, the aura may be said to be the *only* substance in nature, since the electrons are formed out of it, being discreted by motion, and matter is made up solely of the electrons and their attached electronic atmospheres.

Before we can go any farther, something must be said of forms. Here reference may be made to *Divine Love and Wisdom,* n. 174:

> As regards the Atmospheres, which are called Ethers and Airs, they are alike in both Worlds, the Spiritual and the Natural, with the difference only that they are spiritual in the spiritual World, and natural in the natural World. The former are spiritual, because they have their existence from the Sun which is the first proceeding of the Divine Love and Divine Wisdom of the Lord, and from Him receive within them the Divine fire which is Love, and the Divine light which is Wisdom, and carry

hese down to the Heavens where the Angels dwell, and cause he presence of that Sun there in things greatest and least. The spiritual Atmospheres are divided substances, that is, minute forms, originating from the Sun. As these each singly receive the Sun, its fire, distributed among so many substances, hat is, so many forms, and as it were enveloped by them, and empered by these envelopments, becomes Heat, adapted finally o the love of Angels in Heaven and of spirits under heaven. The same is true of the light of the Sun. In this the natural Atmospheres are like spiritual Atmospheres, that they also are divided substances or minute forms originating from the Sun of he natural World; these also each singly receive the Sun and conceal its fire in themselves, and temper it, and carry it down as heat to earth, where men dwell. The same is true of natural light.

The natural atmospheres are here said to be "divided substances or minute forms originating from the sun of the natural world." There are, indeed, vast complexes which we call atmospheres; but in entering upon their study it is best at first to consider their least forms; because unless we an visualize these initial units, it is hopeless to try to comprehend their grand complex. It is impossible to grasp all of the remote consequences of the inter-blending of these least forms; but if we can see that they exist and can demonstrate some of their properties from the facts of nature, the mind has something fundamental on which it can rest, and we can readily admit the remoter consequences, even though we can not definitely comprehend them in all their complexity.

In the *Principia*, after nine chapters devoted to first principles and to the description of two different orders of elementary" particles, Swedenborg begins his tenth chapter of Part I, on "The Existence of the Sun and the Formation of the Solar Vortex," with these words:

> No longer dwelling merely upon parts and particles, I shall now proceed to compounds, large spaces, systems, and the world itself; from the goal we shall go into the open plain; and, from the principles already laid down, contemplate the existence of the sun and the vortex forming round it, both of which are yet in a state of infantile existence. As, however, we now come to treat purely of contingencies, causes must be partly conjectured, and partly derived from the connection existing between our principles.

Here Swedenborg says in so many words that he is guessing, and that after more than 220 pages of explanation, he must proceed to a further development of causes, partly by conjecture, and partly by the application of the preceding "principles" which are themselves speculative. If it were not that, from this point on he begins to adduce facts of nature confirmative of his principles, we should dismiss the whole argument as purely fanciful; and it must be admitted that the speculation stands or falls according to the degree in which it meets or fails to meet the experimental and observational evidence. It behooves us, therefore, to examine this system on its merits as a conjectural one, prepared to find that some of the suppositions were bad guesses and some of them good ones, while it may be necessary to modify the system extensively, either as a whole or in part Thus clearing the ground of useless rubbish, there must be no hesitation in questioning these conjectural principles Only those can be admitted which will survive the mos searching criticism.

I begin by questioning the hypothesis that the particles o the "elements" are expansile. We read (*Principia*, Part I Chap. IX, n. 1): "According to our hypothesis, the firs elementary particles next the sun are most highly compressed; and in consequence of the compression, cease t be elementary, and exist as finites of the third kind." Als since the first elementary particle is said to have a center of *"gravity"* (Part I, Chap. V, n. 8 *bis*), we must assume that this compression is attributed to gravitation, and that the particles of the first element are supposed to be subject to gravitational control, and therefore to possess mass. I will merely note here that two varieties of "first element" are described of which the second fits the electron and that it can be shown that there is no gravitation before the electronic stage is reached, and that the *orbital* motions of the electrons themselves cannot be due to gravity. (For the proof of this see Page 152, Chapter V.) But if we may assume that the first elementary particles of Swedenborg having the vortical form are the electrons,* then, since the charge on an electron is known to be constant, these particles already *and always* are at the highest degree of condensation. If it were possible for them to expand, the electronic charge would diminish, since the electric charge of a sphere varies inversely as its radius when the radius changes.

The same assumption of compressibility is made concerning the particles of our author's second element which he calls the "magnetic element," but which we have every reason to believe is really the *atom* formed out of *electrical* elements, *i. e.,* revolving electrons. We read: "The second elementary particles may be compressed and expanded in the same manner as the first. . . . The particles which are nearer the sun and are in a greater degree of compression tend to a lesser gyration and circle; and those which are farther from the sun or in a less degree of compression, tend to a greater." (Part I, Chap. IX, n. 4). These also are said to have a "center of gravity," which is true if we can identify them with the atoms. We have seen that the electrons are incompressible.

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* For the discussion of this point see page 28 et seq.

Similarly in Chapter V of the Third Part, "On the Ether or Third Element of the World," the ether particles are said to be eminently expansile. But there are conflicting statements in this chapter. Thus in No. 8 the etherial particles are said to have elastic properties *opposite* to those of the enclosed first and second elementaries. But in No. 15 we read: "Now because this particle owes its elasticity to the enclosed particles, which are themselves most highly elastic, we have therefore the *same* ratio of elasticity in the enclosing particle as in the enclosed particles." The last is obviously the only consistent version,* for the elasticity of the compound particle must be the result of the combined elasticities of its components and must follow the same law. However, if we are to identify the first and second elementary particles with the electrons and atoms, the ether particle cannot be composed of these, for it is even less massive than an electron. (Compare its mass as given by the "Einstein effect" at the sun's limb).

The air particle also is said to be equally expansile with the ethereal particle (Part III, Chap. VI, n. 5).

Throughout the series, the assumption is made that unless the particles are expansile and contractile through wide ranges, they can not be elementary, the meaning being that unless capable of altering their volumes, the particles can not keep in contact and form part of a continuous medium. This assumption may now be successfully challenged. Elasticity does not necessarily proceed from change of volume. It may be due to distortion of figure; and while contact of particles is theoretically necessary for continuity in an *initial* extended medium, its place may be taken in subsequent particles by fields of force in the primal element.

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*Unless we assume that reference is made to an outwardly increasing gradient of pressure in the electron, as contrasted with an outwardly diminishing pressure-gradient in the encompassing ether. This relation is one which I believe to be probable, and I am personally responsible for a statement to that effect, but there is no reason to suppose that Swedenborg knew of such a relation.

All known facts confirm the statement that the least particles of the several media have either fixed or only slightly varying dimensions. The least particles of the primal aura (a medium which, according to Swedenborg, has certain properties which are the very origin of magnetism, although he called the second element from this the "magnetic" element *par excellence*) are everywhere in contact. In identifying the second elementary particles with the *atoms* of the chemical elements, we reach one more point of contact with present-day theory; for science now concludes that the magnetism of iron resides in its ultimate atoms. To make a bar of iron magnetic, it is only necessary to swing its atoms into positions of parallelism with like poles pointing in the same direction. Swedenborg was in fact the first to propose this explanation, though he thought that the minute particles of the iron were surrounded by "vorticles" whose spheres of motion can coalesce into a general magnetic vortex when their rotations are similar (which they are when opposite poles of the vorticles are conjoined as in Fig. 3, *Principia,* Part 2, Chap. I), but which conflict when the oppositely turning rotations of like poles meet (as in his Fig. 4). He compares these magnetic vorticles and their penetration to the "undulations of the ether" (*Ibid.,* n. 7) which "may mutually extend themselves into each other's sphere; and thus, as far as regards motion, the sphere of the one may enter into the sphere of the other." In his Fig. 19 he represents the axes of the vorticles in unmagnetized iron diagrammatically by straight lines in helter-skelter positions; but in Fig. 20 the lines are shown all parallel to represent their positions after stroking by a magnet. "If the iron therefore is made to approach the magnet till it comes into contact with it, then the vorticles existing in each body are joined by the most curvilinear and rapid spirals; consequently the vorticles which float in the iron freely, as it were, are reduced by a strong mechanical force to the same arrangement; and consequently those also which flow without. Hence by means of friction, all the parts which are in a state of perfect or partial freedom, are converted into such an arrangement, as to be able to form, with those which surround, a regular sphere and figure" (*Ibid.*, n. 30). "Since the magnet is surrounded with effluvia both at the polar walls and at the equinoctial [equator?], that is, both above and below, both directly and obliquely, the vorticles of these effluvia necessarily coalesce, by a similar motion of all, into one sphere; but this can be done mechanically only from pole to pole by a regular incurvation and figure" [mapped out by the magnetic phantom]. . . . "The sphere of the vorticles thus connected may endure for a considerable time round the whole magnet; nor is there any need for it to be constantly renovated with fresh effluvia" (*Ibid.*, n. 18).

This perhaps implies that the "flow," elsewhere mentioned, is within each vorticle and is not a continuous flow of magnetism along the lines of the magnetic phantom, but that the vorticles, of which these lines are composed, are to be regarded as constituting temporarily fixed chains of polarized particles, which agrees with present opinion. Still the language quoted above would be best satisfied by the conception of a continuous stream-motion in the vortical element; and an experiment described in Chap. VI, Section E, supports this interpretation as being a fact. However, in Swedenborg's Fig. 8, he represents the vorticles as expanding with the increase of their distance from the magnet. This is evidently the origin of his conception that the particles of the universal atmosphere expand and contract through a wide (in fact an enormously wide) range. For, as his figure shows, he has assumed that *all* of the particles of the aura, included in the magnetic sphere of a given magnet, are directly concerned in the general vortical movement. This hypothesis is not warranted, because only a few of the particles of the surrounding medium are arranged in the polarized chains—at least this was Faraday's idea of what he named a "magnetic line of force." The strength of the magnetic field is given if the number of lines of force cut by a unit of rectangular section is known. With this emendation, Swedenborg's conception of the nature of magnetism has a certain general agreement with modern theory.

The particles of the primal medium within and at the boundary of an electron may vary their dimensions reciprocally through the diminution and increase of pressure to which they are subjected respectively in these situations, and they must everywhere be expanded into mutual contact in order to transmit the tremendous forces of gravitation in a moment of time; but the very uniformity of this mighty force implies that the particles engaged in the transmission, are uniform. If the particles were not in contact, there would be lost motion and the transmission of gravitation would not be as nearly instantaneous as it is.

As was remarked above, there is good reason to believe that the primal particles are slightly deformed or condensed immediately outside the surface of an electron, but are expanded within its interior; for the electron consists in precisely such a local inequality of distribution of the ultimate particles of the aura, produced by an exceedingly rapid vortical motion around local centers in the primal medium. The wonderful elasticity of the aura perhaps implies that its particles *might* expand greatly if they could be forced apart, but this would require enormous power and hence cavitation of the aura does not occur.

The electrons, however, are not in mutual contact, but are spaced according to electric fields of attraction and repulsion, and yet they have the most rigidly fixed and uniform dimensions of any entity in nature, determined in all probability by the fact that the tension at the electronic surface can not exceed the breaking strength of the aura. The atom is the last of the strictly vortical particles and therefore must be identified with Swedenborg's second elemental particle. Consequently, the supposed magnetic properties of the latter must be entirely due to the revolutions of the first elementary particle which thus plays a double role as the instrument of both gravitational and magnetic attraction, the first by its pulsation, the second by its revolution.

The ether particles convey such perfect images of the states of motion of the electrons and are so intimately related to the electron in both emission and absorption of radiation that they can hardly be otherwise than of identical dimensions, *while in the condition of radiant ether*. The interference of light is produced not by contact at the surfaces of the ether particles,—or *etherions*, if I may so name them,—but by mutual action between widely extended and interpenetrating electromagnetic fields by which the light-bearing etherions are everywhere accompanied.

If there are free etherions, not immediately attached to the electrons but forming a permanent ethereal envelope attached to the Earth as a whole, and not passing forth continually into space as radiation with the speed of light, but relatively quiescent, these free etherions must differ from those attached to the electrons and may perhaps form the bound ether of variable density (that is, having particles which may be more or less expanded) by which the refraction of light is produced, and which is carried along by flowing water, etc. It is conceivable that there may be such a medium as this, or that there is a shell of non-luminiferous ether more extensive than the air, and that its particles are oscillating very slowly so that they may be brought under the control of the activities of brain cortical cells. These cerebrations are immeasurably slower than the vibrations of light, but they may be of a magnetic nature and capable of acting upon free and somewhat quiescent etherions; for the luminiferous etherions produce and carry with them complex oscillating magnetic fields, and one can see no reason why telepathy may not make use of a reversed process. The fact that a telepathic impression may be transferred to a piece of paper and can be carried through space, conveying attendant psychical impressions to a recipient, calls for a *material* medium to serve as a conveyor of vibrations, as well as for a sentient and harmonically attuned eceiving instrument in a second distant but sympathetic brain. "How far this atmosphere [the ether] penetrates nto the natural mind, and whether it presents material ideas, as they are called, or fancies and imagination, cannot as yet be so well established, but from many things it appears probable" (*Spiritual Diary*, n. 222).

Finally, the atoms, which are formed out of the electrons, have pretty definite volumes which do not vary much for a given species of atom, at least not as long as the ionic tate remains unchanged; and the expansion of gases by eat is not an enlargement of the molecules, but an increase f their translatory kinetic energy whereby they are pounded farther apart and the length of their free paths is increased.

These facts require the abandonment of Swedenborg's hypothesis of indefinitely *expansile* elementary particles. Effective contact between dispersed particles, subsequent to those of the primal medium, is equally well provided for by interpenetrating fields of force, or by motions of various sorts and their kinetic energies, while the transmission of powerful gravitational stresses by the aura proves that its particles can grasp each other by their conflicting rotations in spite of their elasticity and freedom from friction.

What then shall we say to Swedenborg's statement that there are several atmospheres, and what is their number? I will quote from my review of the *Principia*:

> The description of the "first" element is couched in terms wholly spatial; yet an intermediate, or even a purely spiritual atmosphere, perhaps animating the second, or magnetic element (assuming the latter to be the medium which fills space), would clear up those discrepancies in our author which speak sometimes of the natural atmospheres as three in number, but elsewhere as four. These things may be seen as in an image if we compare the three atmospheres of the natural world with the three degrees of heavenly life which receive as many successive openings of interior power from more and more perfect reception of life from the Lord, and then note what Swedenborg says of the heaven of human internals "above the inmost angelic heaven; wherefore these internals are the habitations of the Lord Himself" (Arcana Coelestia,* n. 1999). This heaven of human internals which is beyond even the angelic consciousness, and which can not be controlled or interfered with in any way by finite beings, is a holy of holies in which the Lord dwells.

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* In referring to this, the greatest of the writings of the Prophet of the New Jerusalem, let me say that the full title of the first volume reads: "The Heavenly Arcana disclosed which are in the Sacred Scriptures or Word of the Lord, here those which are in Genesis, together with Wonderful Things seen in the World of Spirits and the Heaven of Angels."

It appertains to man and yet partakes of the Divine, that is, this heaven of human internals is an intermediate between the finite and the Infinite. Similarly, nature is connected with the spiritual world through an intermediate which appears to be what Swedenborg means when he names a fourth atmosphere, namely, a connective which is in space, but not of space. (New-Church Review for April, 1913, pages 169-170).

I think that this is a permissible view in some respects, but there still remain difficulties which suggest a different treatment of our author's obviously fluent or changing conceptions.

In the first place, I wish to modify my suggestion that possibly the "second element" is the same as the magnetic "aura." This I now see is inadmissible. True they both have magnetic properties, but with a difference; for the second element exercises its magnetic effects by taking hold of the aura through the revolutions of its electrons, and not because it is identical with the aura. Without abandoning the idea that there is an intermediate, hinted at by Swedenborg where he speaks of a fourth atmosphere, I shall show presently that this must be placed *before the "first element."* This new interpretation not only removes some of the seeming discrepancies alluded to above and harmonizes well with recent scientific discoveries, but it is suggested by the fact that Swedenborg himself gave *two different* or alternative forms of his "first elementary" particle. If these are regarded as successive distinct entities, the second derived from the first and of a wholly different order of magnitude, we have *three orders of vortex particles* and *three of spherical particles* with the first members of either series coinciding. But the subject is too involved for mere cursory elucidation and will be resumed. (Page 74 *et seq.*) In fact, though formed out of the aura, neither the first nor the second elements are co-extensive with it, but, on the contrary, they are exceptionally restricted and localised. The aura itself must be distinguished from the spiritual atmospheres because it fills space, indeed, may be said to produce space.

As to what is meant by the "actives of the first and second finites" which are said to activate the interiors of the second elementary particles, I am inclined to consider them as *spiritual* atmospheres, inaugurating and maintaining by their influx the revolutions of the nucleus and the electronic motions which give individual light-rays. No other interpretation fits so well with what Swedenborg says elsewhere of this border region of the intermediate. Rev. C. Th. Odhner has put the case succinctly in what he says of Swedenborg's doctrine of the point—a thing without spatial extension, but surely Swedenborg was not talking about the geometrician's point when he says that "in the point, or in the effort of the point, lies concealed the whole power, both active and passive, of mechanically producing, in just order and in regular succession, all finites whatever, or the world at large, both with respect to its smaller and simpler parts and its greater and composite ones." (*Principia*, Part I, Chap. II, n. 22.)

Consequently, when we read (*Ibid.*, n. 2) that "geometricians ascribe the origin of all their figures and bodies to such a point, yet not as belonging to the scheme itself, because that is incapable of defining it in a geometrical manner. Thus geometry seeks for its origin beyond itself, deriving this point not from itself, but from rational philosophy,"—he is speaking in the language of parable.

And when, further, he says of the first or simple finite (Chap. III, n. 7): "It fills space but is the smallest among the finites, or is such that there cannot be anything smaller

Since it is limited, it will, among finites, fill space. If there are more boundaries than one, there must in this case, be a distance from one boundary to another or space from one limit to another. This we cannot predicate of a point, which possesses only one limit; unless we predicate it by way of analogy to its internal motion,"—he appears to be still speaking symbolically. It is difficult to reconcile the statement, that this is said of the point "by way of analogy to its internal motion" or in respect to an ideal created effigy in speaking of the first finite, with the statement that this form "fills space," unless this means the superspace of the spiritual world. It should be said that, while the first finites are constituted in superspace, their actives enter the space of nature and form it, and fill the interiors of the first elementary particles.

I have noted above that the electron is the first particle which is subject to gravity. Swedenborg had no knowledge of the nature of gravitation. He says very little about it and where he does venture a few remarks, they are often obviously erroneous or self-contradictory. For example, in *Principia,* Part I, Chap. VII, section on "Actives of the Third Finite," he says: "With regard to weight, it does not appear that we can speak of it as predicable of the third finite; but instead of it we substitute mass; for there is no medium in which the finite flows, and consequently no weight can be perceptible." Here he is evidently under the baleful influence of the Cartesian doctrine of the cause of planetary motions. He thinks that gravity requires the *flow* of something. The planets, he thinks, are carried around the sun in the flow of a circulating vortex-current. Moreover, "mass," as ordinarily understood, implies both gravitating acceleration and weight. so that the substitution of this term does not change anything essentially.

Certain men of science who have taken a hasty glanc
at the *Principia,* having found these crudities in regard t
gravitation, have concluded that the author was hopelessl
wedded to the Cartesian system of vortices and have bee
deterred from reading further (to their own loss) on account of this "fly in the ointment." Let it be noted t
Swedenborg's credit that he demurs a little and seems t
sense that something is wrong; but he is so overwhelme
by the prestige of the Cartesian philosophy among th
learned institutions of Sweden in his time, that he fails t
shake off the incubus.

Professor Arrhenius, in his introduction to the secon
volume (*Cosmologica*) of the edition of Swedenborg'
scientific works now appearing under the auspices of th
Swedish Royal Academy, compares his ideas with those o
Des Cartes and says: "In Swedenborg's work no othe
change is made in these conditions than that the number o
particles is increased and an attempt made to derive all o
them from the mathematical point. This section is not o
particular interest." Dr. Becker also, in the course of a
article on Kant's cosmology (in the American Journal o
Science, (4) Vol. V, page 97, February, 1898) alludes t
Swedenborg, but considers that he has nothing better t
offer than the obviously incorrect Cartesian scheme. W
admit that an author is responsible for his mistakes; bu
are not snap judgments, founded on very imperfect stud
mistakes? If Arrhenius had studied his subject more extensively he would have found Swedenborg saying:

> Unless an idea is formed of God as the primal Substance a
> Form, and of His Form as the absolute Human Form, the huma
> Mind may easily involve itself in spectral imaginations abo
> God himself, the origin of man, and the Creation of the Worl
> It would then conceive of God only as the nature of the u

verse in its first elements, thus as its vastness, or as emptiness and nothingness; of man's origin, as a fortuitous concourse of elements into that form; of the creation of the world, that the origin of its substances and forms was geometrical points and their lines, which are essentially nothing, because nothing can be predicated of them. (True Christian Religion, n. 20.)

It is acknowledged by many that there is an only substance, which is also the first, from which all things are; but what that substance is in quality is not known. It is believed to be so simple that nothing is more simple; that it may be likened to a point, with no dimension; and that from an infinite number of such the forms of dimension have their existence. This, however, is a fallacy, originating from the idea of space; for, from this idea, there seems to be such a least thing; but still the truth is, that the simpler and purer anything is, the more and the fuller it is. For this reason, the more deeply any object is examined, the more wonderful, perfect, and beautiful are the things seen in it; and thus in the first substance are the most wonderful, perfect, and beautiful of all. This is so, because the first substance is from the spiritual Sun, which, as was said, is from the Lord, and the Lord is in it; thus that Sun is itself the only substance which, as it is not in space, is the all in all, and is in the greatest and the least things of the created Universe. Since that Sun is the first and only substance, from which all things are, it follows that there are in that substance infinitely more things than can appear in the substances originating from it, which are called substantiated, and at length matter; they cannot appear in these, because they descend from that Sun by degrees of a twofold kind, according to which all perfections decrease. Hence, as was said above, the more deeply any thing is examined, the more wonderful, perfect, and beautiful are the things that are seen. (Angelic Wisdom Concerning the Divine Providence, n. 6.)

Just imagine that we could turn Swedenborg's "point" inside out! It seems to have a whole nonspatial universe included within it. Mr. Odhner says that Swedenborg's first natural point "is the Nexus between the Infinite and the finite,—the Only-Begotten of the Father,—the Word which was in the beginning with God, and which became Flesh and dwelt among us." Thus it is "the starting point!" (New-Church Life, Vol. XXVII, page 688, also page 476.)

In the same journal (Vol. XXVIII, page 231), Mr. Odhner states his belief that the first and second actives of the *Principia* are not material forms, but are the "radiant belts above the atmosphere of heaven, round about the spiritual Sun." As these are media, they are needed in the formation of all successives. Swedenborg tells us that "the Truth which proceeds immediately from the Lord, inasmuch as it is from the Infinite Divine, cannot possibly be received by any finite Living substance . . . Wherefore the Lord created successives, by which as media the Divine Truth immediately proceeding could be communicated. But the first successive from this is too full of the Divine to be received by any. . . . Therefore the Lord created another successive by which the Divine Truth immediately proceeding might be as to some part receptible; this successive is the Truth Divine which is in Heaven. The first two are above the Heavens, and are as it were radiant belts from the flaming, and encompass the Sun." (*Heavenly Arcana* n. 7270.)

These "belts" may be compared with the successive envelopes of the sun of nature which appear like belts and by their absorption of the sun's rays, temper the heat received by the planets. The present proposition is, tha similar media temper the Influx in the creation of the leas things of nature. Mr. Odhner points out that "the create or finite substances of the spiritual Sun are identical wit the first finites of the *Principia*:

(1) Both are the first things of creation and finition
(2) Both are created out of the Infinite by means o motion.

(3) Both are described as the most perfect of all things finite.
(4) Both are the minima and most simple things of creation.
(5) Both possess the animatory or heart-and-lungs motion.
(6) Both are in the form of a vortex-ring.
(7) Both possess the power of finiting all other things in the universe.

Consequently the two are one and the same thing."

The only escape from this conclusion is in the supposition that there is a precise duplication of means in nature and in the heavenly world, connected and unified by correspondence. Some will prefer this point of view. "Recognition of the spiritual world, as the foundation of the material one," says Grindon (*Life, Its Nature, Varieties and Phenomena,* page 192), "and in connection with it, of the momentary influx of the Divine life into every object and atom of creation, the spiritual world receiving that life primarily, and the material world by derivation from it, is the beginning of all genuine philosophy." We may agree to this as the origin of the visible forms of nature; but are not the inmost energies of the atoms of immediate derivation from the Divine? If the resurrection body of the Lord is Divine-substantial by uplifting to the Divine plane of Life itself, the Divine Influx into the assumed body of flesh, and into every other material form as to its inmost energy, must have been immediate—and withdrawal into the Inmost means that Jehovah has taken to Himself what was His Own, in order that with what was once a small part of this little Earth, He may rule the Universe. "We give Thee thanks, O Lord God, the Almighty, who art and who wast and who art to come; because Thou hast taken Thy great Power and didst reign."

In subscribing tentatively to Mr. Odhner's interpretation, I do so because this view seems to me in consonance with Swedenborg's inmost thought, expressed in the earlier work in a halting way, with repetitions and inconsistencies, but gradually progressing into a clear rational light. In the *Principia* he says that "the active of the third and second finite may be simultaneously in one space," also the active of the second and first; but "the actives of the third and first finite cannot be simultaneously in one and the same space; since in consequence of the difference between their velocities, circles, and dimensions, the circles and motions of the first active would be thrown into utter confusion, and either these would be expelled thence or else the active would become absorbed." ("Actives of the Third Finite," n. 7.)

The differences here are expressed wholly in spatial terms, yet the avowed incompatibility of the actives of the first and third finites is entirely consistent with the supposition that this is a first and imperfect attempt to describe the discrete degree between these forms. We may notice that the electron, or "first elementary particle" of the vortex-ring type which is so intimately concerned in the production of natural light, is, on this view, of right associated with the active of the *second* spiritual finite which is the recipient of the spiritual light of truth as the electron infills the light-bearing etherion; but the atom, being the second and final elementary particle, must include forms associated with an influx of both love and wisdom (finited spiritual substances of *both* first *and* second active finites *) in complete trine.

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* The "second actives" of the first element contain within them subsidiary first finites as constituent particles (see Part I, Chap. 8, n. 2); but in the second elementary particles the first and second actives stand in an equal footing, and not one subordinate to the other. Their union is a marriage relation.

iewed correspondentially, that is, from spiritual thought, is apportionment of the actives of the first and second nites is eminently reasonable; but the attempted explanaon from things of space and time is not convincing.

Turning to the *Intercourse Between the Soul and Body,* e learn that origins can never be comprehended by dwellng in the things of space and time. *Influx* from the spirital world is absolutely necessary to sustain the inmost ructure of matter; and this influx can not be correctly escribed in spatial terms. The connection of matter with pirit is through correspondence. Here lies the very source f power.

> Spiritual things cannot proceed from any other source than rom love, and love cannot proceed from any other source than rom Jehovah God, who is love itself; wherefore the Sun of the piritual world, from which all spiritual things issue as from a ountain, is pure love, proceeding from Jehovah God, who is in he midst of it. That Sun itself is not God, but is from God, and s the proximate sphere about Him from Him. Through this Sun he universe was created by Jehovah God. By the universe all he worlds in one complex are understood, which are as many s the stars in the expanse of our heaven. . . . The created niverse is a coherent work, originating from the Divine Love hrough the Divine Wisdom. . . . That the Divine fills all things, and by filling preserves all things in the state in which they were created, reason has a distant view of, and also a near view, so far as it is acquainted with love as it is in itself; with its conjunction with wisdom for the perception of ends; with its influx into wisdom for the exhibition of causes; and with its operation by wisdom for the production of effects. (Intercourse Between the Soul and the Body, n. 5.)
>
> From no other source than from the creation of the universe and finally of the earth, and of all things in the former and the latter, can it be better seen that the Divine Love which is Life itself, and which is the Lord, is in the form of the forms of all uses, which form is man; for from creation there is not any-

> thing given upon the earth which is not for use. The who mineral kingdom is full of uses, nor is there in it a grain dust, or a clod of dust, which is not for use. The whole vegetab kingdom is full of uses, . . . The whole animal kingdom is als full of uses. . . . In a word, every point of what is created a use, yea, is in a series ascending from use in first principl to use in last, thus from use to use continually, a manifest pro that the Creator and Former, who is the Lord, is the infini complex of all uses, in His essence Love, and in His form a ma in whom is that complex. Who can possibly be so insane ar irrational (if he be willing to submit the above consideratio even to the judgment of common sense) as to think that tl above effects are produced by a dead sun, and thence by a dea nature? (On the Divine Love, n. 8.)

The description of the initiaments of creation given in tl *Principia* seems to be an imperfect version of a teachin for which, in its fulness, we must consult these later wri ings. If the *Principia* is a distinct advance on the author youthful productions in the "Chemistry," etc., still mor remarkable is the completeness and power of his grasp c philosophic thought after his illumination. The earlie scientific writings may tax the comprehension of the unin itiated from their profundity, but, compared with the fu blaze of glory of the subsequent unfoldings, they appea relatively speaking, immature.

Natural science is today in somewhat the same state tha Swedenborg was in when he was writing the *Principi* Slowly, haltingly, through a maze of contradictions, scienc is gradually lifting the veil of the unknown. A distinguishe zoologist has said: "Probably the foremost significance c reason in the human animal is that it is the device or agenc developed by nature to relieve the species from the unce tainty and precariousness of material sustenance as instinc alone is able to secure it." (Professor William E. Ritter i Science for August 8, 1919.) To the question: Is natur hen, rational? Does the volcano whose eruption destroys hundred thousand lives in a moment of time, *argue* that here are too many human beings, therefore they must be viped out? Are the forces of nature of a higher order han those of human life? If not, can that which has no ower of rational thoughts produce what is higher than tself? Natural science hesitates to reply. Natural science an recognize the crudities and absurdities of a position vhich is as impotent as would be the attempt of a man o get over a fence by pulling at his boot straps, and yet s with difficulty persuaded to go through the gate which as been providentially opened and which gives ready access o the treasures of the "Temple of Wisdom."

Without abandoning the idea that there may be need of n intermediate atmosphere to serve as a connection between he spiritual and natural worlds, and while admitting that n some phases of his thought our author is probably considering such an intermediate atmosphere, there are other allusions to four distinct entities which ought not to be confounded with the above order of sequences.

I will refer to my condensation of the quadruple order of forms of the *Principia* (April, 1913, New-Church Review, page 186).

"*First element* = a third finite consisting of a shell of first finites which inmostly are simples, inclosing an aggregation of active second finites.

Second element = a surface composed of third finites [first elementaries] and an interior of actives of the first and second finites. [Compare with Odhner's argument noted above.]

Ether = a surface of fourth finites inclosing first elementaries and *bullae.* [*i. e.,* the ether particle is formed originally around a first elementary particle, or electron, an is, as it were, a tiny electronic atmosphere.]

Air particle = a surface of fifth finites inclosing first an second elementaries and *bullae*." [*i. e.*, an air particle is molecule enclosing atoms and their electrons.]

The scheme includes two orders of *vortical particles* an two of *spherical particles*. But it is not necessary to mak out of these particles *four* distinct *atmospheres*. After muc study of the subject, I am led to the view that the *first* elementary particle of the vortical sort is probably none othe than the electron—the first particle to possess mass an gravitational force, the unique electrical unit, the basic substance of the atom and the beginning of what we call matte by which we mean that which possesses mass. But ther is not such a thing as a permanent electronic "atmosphere or atmosphere consisting of electrons. As *a thin layer*, small number of electrons may be attached to an "electrified body; but the condition is unstable and soon passes awa It is rather stretching the meaning of terms to call thi excessively thin layer an atmosphere. The ether is the atmospheric representative of the electron. Every electro forms around it a shell of ether. These ether-shells ar continually being thrown off from every material bod whose temperature is above absolute zero, and as sphere of radiant ether they constitute a vast assemblage of radiant "atmospheres." The advancing spherical shell of suc an assemblage, forming an instantaneous flash of light, endlessly expands, but not the discrete individuals. It is possible that there may be quiescent atmospheres of ether, a suggested already, and that their particles expand to muc larger size, but this awaits proof.

The universal interstellar atmosphere is the aura, and i also composed of spherical particles, but these differ fro the elementary vortices and require separate consideration. (See page 84 *et seq.*) These particles, I take it, are perpetually receiving Divine Creative Influx, either through the spiritual atmospheres, or else immediately from the Creator, and this inflowing of sustaining energy is Swedenborg's *conatus.* The aura is the supreme natural atmosphere, the beginning of space and the physical instrument of magnetism. The aura is separated from the lowest spiritual atmosphere by a discrete degree, but is wholly dependent on what is supernatural for its own energy and perpetuation. In this aural atmosphere are the gravitational forces centered in the electrons, by which the Earth is tied to the sun with a power which can be likened to the tensile strength of a million-million round rods or pillars of steel, each thirty feet in diameter as calculated by Lodge.

The atmospheric trine in nature is as follows:

(1) Out of myriads of spherical particles which constitute the universal atmosphere, there is produced by a special vortical motion which increases in speed to that of light at the surface of the particle, a new vortical form, namely:

(2) The *electron* or least particle of electricity and its attendant ethereal envelope.

(3) From some thousands or hundreds of thousands of electrons there is formed the *atom* whose chemical and physical properties vary according to the number, arrangement and motions of the included electrons; and these atoms, either singly as ions, or in groups as molecules, are aggregated into a lowest "aerial" atmosphere always attached to some earth or comet, or constituting essentially the entire bulk of some sun, or in its initial status composing some gaseous nebula.

Now if we recur to the definition of three discrete degrees of atmosphere with which we commenced, namely:

"The atmospheres which are called ethers and airs, from highest to lowest, that is, from the sun to the earth, are separated into such degrees; they are like simples, collections of simples, and again collections of these which taken together are called a composite," it will be seen that the definition does not apply to what we understand by an "atmosphere," which is a widely extended medium; but the definition distinctly applies solely to the individual particles, namely, the aforesaid "divided substances or minute forms," of which such atmospheres are composed. Moreover, while the particles of the aura and those atoms which, by reason of a sufficiently high temperature, are in the gaseous state, do aggregate together into widely extended atmospheres, this term is less applicable to the aggregations of free electrons.

When electrons are free, several different cases occur, to neither of which is the name of atmosphere particularly applicable. Thus electrons are produced by the breaking up of atoms in the sun, and these free electrons are emitted by the sun as streams of cathode rays which pass rapidly through space. These streams are not emitted uniformly from all parts of the sun's surface, neither are they given out continuously, but spasmodically and from special centers of disturbance. Thus while these cathode rays from the sun are rather widely extended groups of discrete particles which travel together for a while and thus have a certain atmospheric analogy, the groups eventually break up and lose all resemblance to an atmospheric form in the usual sense of this name.

Again, when a body becomes electrified, there emanates from the excessively thin shell of free electrons attached to its surface, a field of so-called "electric force" which encompasses the body like an atmosphere and really simulates a sort of atmosphere; but the electric field does not consist of electrons. The electric field is composed of polarized aura, that is, of chains of particles of the aura (aurions, if I may so name them) radially disposed and forming radial vortex-filaments in the universal atmosphere, on account of the electric stresses in that medium.

An electric current in a conductor is a stream of electrons flowing locally under the influence of a potential gradient. In a vacuum-tube or an electric arc, such a stream has a number of properties which might be classified as atmospheric, but one would hardly wish to call the electronic stream an atmosphere. The atoms which are caught up and which color the arc, are foreign material in respect to the electric current itself. The current is also surrounded by rings of aurions.

Neither of these arrangements of either electrons or of polarized aurions constitutes, strictly speaking, a second or middle atmosphere. They all lack that condition of permanence which the term seems to imply. More to the purpose is the conception of an "atmosphere" of light surrounding the sun, or which emanates in a small way from every radiant thing. This also, if it were not perpetually renewed would cease to be, nor should we be aware of its presence were there no matter for it to shine upon and illuminate. Yet so long as the warmth of fire persists, the light goes forth into its perfect sphere. Here, however, although the wondrous garment of light is thrown off by the electrons, it does not *consist* of electrons in its least parts, but of tiny electronic images—the light *quanta,* or free vibrant ether particles (etherions), speeding away through space with that marvelous velocity which even thought can scarcely follow.

As permanent or quiescent atmosphere, the *bound* ether is so closely attached to electrons that it can hardly be called a general atmosphere, but is rather *an innumerable host of separate and very minute electronic atmospheres.* It is, however, just possible that there are etherions, differing in structures from electrons, though of the same or not very unlike size, which remain loosely attached to matter and constitute a general atmosphere of *non* luminiferous ether wherein human spheres of thought and affection reside, clad for a short time in a physical form with a structure which enables them to be recognized by suitably endowed clairvoyants. This is an attractive speculation, and it does seem as if there must be some such physical basis for telepathy and possibly for certain classes of apparitions. At least it is well to keep an open mind ready for new evidence in this direction.

The aura, or "the first and most universal element of the world-system, or the first elementary particle compounded of finites and actives," is described by Swedenborg under two forms. The first, shown in his Figure 11 of the *Principia* (Part I, Chap. VI) is a spherical bullular particle, "the internal space of which, or EEE, consists of actives, and the external surface ABCD, purely of finites."

"Before anything elementary can exist," we are told, "it is necessary that in the world there should be two things, one active and the other passive; one which is perpetually in local motion, another which is not in local motion. Without these two things no third can be produced which shall partake of the active and the passive; in a word nothing natural can come into being. For nature is the union of the faculty which bodies have of acting and being acted upon with the power and force of inertia." (*Ibid.*, n. 1). These particles are said to possess "a perfectly impressionable and elastic surface." (*Ibid.*, n. 3). The energy which keeps iese particles expanded is thus described: "With regard o internal force, this we find in the enclosed active space. f this space consists of actives only which continually act, nd which can do so in every direction, we are here supplied ith a force on one side of the surface to which some force n the other ought to correspond. Now with regard to the orce on the other side, or the reacting force, we have ob- erved in a preceding chapter that there is an active belong- ng to each point which occupies all the least spaces and lls the interstices lest there should be anywhere a vacuum. his active is present between every one of these elementary articles, and acts upon the convex surface and perpetually eacts precisely as the internal force of the actives acts; he surface is thus kept in equilibrium between two forces." *Ibid.,* n. 5). These interpenetrating "actives of the first inite" join all together, press all into most intimate embrace, nd constitute, as it were, an environment of elemental af- ection and consociation. Why not? Have not the atoms heir mutual affections of chemical affinity? Why not the niversal embrace of a World-Soul?

But out of these spherical particles, capable by their bsolutely uniform presentation in every direction of taking mpressions impartially from every side and from every ort of thrust, Swedenborg conceived an alternative form of he "first elementary particle," in the shape of a vortex-ring, o be produced by pressure. If thus produced, these con- lensed aural particles should be densely packed together nd should be incapable of individual constructive motion. It is safe to say that the electrons are not so built, that they re larger and not smaller than the particles of the aura, in act, that immense numbers of aural particles go to form single electronic corpuscle; and while there is superficial condensation on an electron, within is expansion throug intense activity.

The particles of the aura out of which the electroni vortices are formed, may themselves have a sort of vorticit and it may even resemble in a way that of the electron, a I shall show; but the aurions, or aural particles, must b spherical *or else gravitation could not have its absolutel nondirectional proclivity.* The attraction of two bodies a a given distance is independent of the direction of the lin joining their centers of gravity. While the aurions mus have poles, the poles are all of the same sort, namely, attractive. That they do have poles is indicated by their forming polarized chains—radial for electric force and transvers circumferential for magnetic force. This seems conclusiv Since their poles are of the same name, it seems best no to call these particles "magnetons," as I have done in an other place. Besides, this term has been preëmpted b Parson for the valent revolving electric charge of an atom

From the study of the motion of electrons within th atoms made known by the radio-active transformation from the enormous frequencies of vibration in line-spectra from the Zeeman effect, etc., it is definitely demonstrate that motion involving tremendous energy goes on unceasingly inside the atoms. The long endurance of thes motions proves that the substance out of which the electron are formed (the aura) must be almost devoid of friction that is, with only enough friction to hold the parts togethe but not enough to impede their motion. Everything no known about the entities formed out of this primal mediu confirms the accuracy of Swedenborg's prevision that it primal particles must possess inherent energy, or effort t motion, from which arises "a progressive motion of a the parts and spirals." Though "perpetual motion" doe not exist outside the atoms, it undoubtedly prevails within them.

Swedenborg's general description of the motion which goes on within one of his particles is given in the following quotation from the *Principia* (Part I, Chap. III, nos. 20-23):

> (20) If the continuous motion be spiral it must be reciprocal; namely, from the center to the circumference, and contrariwise. It is evident, I think, that if internal motion be granted, it must, for the reasons given, be spiral. But if the spiral motion be continuous, it must be reciprocal. Without reciprocation, it could not be continuous. Nothing can move in a spiral continuously unless it moves in such a way reciprocally. Without a return motion there is no continuous motion; for there would be no motion from the center to the circumference if there were no return motion from the circumference to the center; in a word, the very continuation of motion consists in reciprocation and alternation. If, therefore, there is reciprocation, and if the motion is spiral, we cannot conceive such a motion taking place mechanically, unless a figure is conceived of such a kind as will admit of this motion and its return; nor even then could there be such a motion and its return, unless in this figure loci were conceived on all sides, through which any point flowing to the surface might afterwards return. Unless there were such loci in the figure, one point in its motion would encounter another; a single point would thus act as the cause of retardation and rest to another, and thus all motion would cease. If, however, there is a regular reciprocation, then on all sides in the figure of motion there must be loci through which the points may return to the center; thus there must also be a way from the center to the circumference and from the circumference to the center, lest one point should encounter another. If, therefore, a reciprocal spiral motion be granted, it must be granted also that, in the space thus comprehended, there must on all sides exist loci through which a reflux and reciprocation may take place.
>
> (21) From the motion of the points, parts, or particles, arises the natural and fixed arrangement of all. Consequently, in a finite, by reason of the spiral motion and arrangement in which it originated, there are two poles, one opposite to the other;

these two poles are formed like cones. Motion always precede
arrangement. Without motion there would be no dispositio
of parts. It is only by motion that parts are united into a
arrangement conformable to the motion and its figure. It i
by motion that parts tend to equilibrium. Motion, therefor
adapts the figure to the position; as is the cause, such is th
effect. It is thus that the parts remain in the position into whic
they ultimately come in consequence of their motion. Now sinc
the disposition or arrangement of the parts is the form of th
motion, it follows, that in this arrangement all the parts co
tinue to move in a spiral, and exercise an effort to motion a
cording to the internal force remaining in each particle. Alread
the parts have such an arrangement that they all tend similarl
toward the same motion, and act simultaneously as one commo
cause; so that there is no part which is not necessary, and whic
is not a part of the motion, and which does not contribute it
own share to the general motion. One part consequently mai
tains a relation to the other; the adjacent, both to the adjacen
and the remote; that on the surface to the intermediate; th
intermediate to the central; the central to that on the surface
and so on regularly throughout the circle [cycle]. Hence ever
part is in series and connection; the motion of one can be th
motion of all as well as of itself; and this in a circle [cycle]
Such a situation of the parts can be obtained only by mean
of the spiral. The communication and the reciprocation of mo
tions, the circulation of whatever kind, when the parts ar
brought into a regular arrangement, are obtained by means o
poles; so that there are connection, contiguity, and motion, ex
tending from one pole to another; so that the motion can, as i
were, pass out of one pole and enter into the other, and thu
pass and repass by continuous circles [circulations] and per
petual spirals. The fact that, in such a motion or arrangemen
of the parts, the poles by reason of the mechanism of the motio
and the geometry of the figures, acquire a cone-like form, wil
be explained in the sequel.

Similarly, in every entity whose parts are disposed into
spiral figure, there are an equator, ecliptic, meridians, and othe
perpendicular circles. If there are poles, and if those are place
apart and enlarged into the figure of a cone, then there will b

polar circles also, the dimension of these being determined by the diameter of the cone. If there are cones and polar circles, there is an equator equidistant from the poles, together with meridians passing at right angles through it from one pole to another. If there is a spiral figure on the surface, as well as in the interior circles, then there are circles of latitude formed by the spirals in the surface; and if these are bisected at right angles, the ecliptic [or component of motion tranverse to the surface spires by which these continually close up on the pole] will pass through the sections. Thus do poles determine meridians and an equator; the spirals determine circles of latitude and an ecliptic; thus also begins the same order in the microcosm which we see in the macrocosm, and thus almost the same takes place in the smallest figure as in the largest, or in that of the world; for even in the larger, before the figures are developed, they are more inflected and curved. All these relations originated solely from the spiral motion. That in these things consist the power and quality of producing a world, such as we contemplate and such as our senses perceive, or, in other words, of advancing the process of its formation to that end in which its phenomena can be placed before us geometrically, or in a manner conformable to its mechanism, will appear in the sequel.

(22) From the regular arrangement of the parts into a spiral figure, arises a general effort of all, tending to one and the same general motion. This effort, if there is nothing extraneous to prevent it, causes a general axillary motion or rotation of the finite round its polar axis. All effort arises from motion. The parts continually tend and put forth an effort towards the same arrangement into which they are reduced by motion; because they tend toward motion so long as there remains in every particle a power and cause of motion. Motion, therefore, adapts the figure to the arrangement, and in that arrangement presents an image of itself. The form of the arrangement determines the effort, together with everything in the effort similar to what is in the motion. In a word, the parts in their own arrangement move by effort toward and tend to the same motion, to which by their own motion they had come. There is an effort and striving toward the same motion, so long as there remains in any particle any internal force. If the points or particles are in

respect to figure, motion, and force, perfectly similar to one another, they must come into a similar relative arrangement, and exercise a perfectly similar effort. Among things absolutely similar there is only one mode, and it is from a mechanical necessity that they flow together, by that mode, into their own arrangement and into no other. Hence arise the force and tendency toward that motion which is inherent in effort. From the regularity of the parts exercising a similar effort the force receives determination and direction. When all the parts, therefore, unitedly associate and combine their efforts towards any given motion, this trend and effort is general or common to all; in other words, it is an effort towards a general motion of the whole particle; a motion which cannot be any other than round its own axis. If we imagine a certain number of particles joined together, and united to one another, every one of which, from its inherent power, is exercising a similar effort to motion; and if these particles similarly cohere in a right line and in a series, then the effort of all is into a right line or into a series; and consequently the motion arising is in accordance with the effort or exertion. If the particles were disposed and connected in their order, not into a right line but into a circle, so that every one of them exercised an effort at the same angle in the direction of the tangent, then from this condition there would arise, were there no impediment, a general effort of all toward the form of their arrangement, or the circle which their motion traces. [It will be observed that nothing is said here of any central retaining force; but perhaps the reacting pressure of a surrounding active is supposed to take its place.] It would be the same, were small points disposed into a spiral figure; for since they have intrinsically the power of self movement, and since they all possess a perfectly similar force arising from their perfectly regular position, it follows that no other effect can exist from this common cause, than one common motion to which they all tend, and to which one impels the other, and consequently, by reason of the connection and contiguity, the whole cohering series also; that is to say, they all tend to a motion round the axis.

(23) From the effort to motion as exercised by all, there arises a progressive motion of all the parts and spirals, but which is

uch slower than the common or axillary motion. In this motion preserved a similar arrangement of all the particles, as also e same figure. If all the points tend to motion in a perfectly imilar manner, and if the connection and arrangement of the arts are such that they may be still further moved, that is to ay, that there may be a figure of motion, then they cannot be t rest; but, in consequence of the inherent force and effort emaining in every point, they mutually impell one another to otion. Let the arrangement of all the parts be assumed to be piral, formed in motion and for motion; and thus presenting uch an equilbrium that the motion of one part is the same with e motion of the other and of all the parts; so that the motion f the center is that of the surface; the motion of the surface hat of all the intermediate circles and contrariwise; it then ollows that all the parts in common are urged into motion. his motion, however, is slower than the common axillary motion, or that of the whole composite; because all the parts cannot move except simultaneously in their contiguity and connection. When a point is moved at the surface, then, according to s situation and connection, a point must be moved at the center, nd also one intermediately between the surface and the center. here is a consent of the parts to the same arrangement, because here is a connection between them. In order, therefore, for the hole to be in motion, the motion [of advance from one spire, r coil of the spiral, to the next] must be slower than the eneral motion round the axis. Indeed this motion can advance nly a single step, while the common motion performs a whole evolution. Nor indeed can the whole series and aggregate of he finite be put in motion, unless, in this motion, one and the ame or a similar arrangement of the parts be preserved. For here is only one arrangement adapted to their figure and motion n which they can be moved as a whole; and unless this is reserved, the equilibrium ceases, as also the mode, belonging o all, of conjoint and united self-movement. In a word, the imilarity and equality of the figure and effort in all being given, here is a mechanical necessity, not only for their flowing together into and composing such an entity, but also by means f such an arrangement, a necessity of preserving itself in every otion, fluxion, and state, of retaining its equilibrium by the

preservation of its arrangements, and of everywhere perpetuall
sustaining itself when given over solely to its own mechanis
Thus it is that the particles in the arrangement, which is mos
perfectly suited for motion, are necessarily self-moved, and i
similar ways; so long as there remains in each such a forc
that one may become the effort, stimulus, and incitement of i
self and of the other. It will be seen in the sequel, that th
motion, which we have called progressive, follows the eclipt
[or path of advance of the spires of the spiral into successiv
positions, moving somewhat as the rotary circulations of
planet advance along its orbit]; or that all the circles of latitu
or spirals accompany one another; and proceed, at equal di
tances and in regular order, around their center.

I have quoted this description in full because, in spite
its seeming prolixity, I fancy that many readers to who
the conception will be novel, will find it necessary to ref
back to it, to see if they have understood it aright. Let
be noted that the particle is "self-moved," and then as
What else can this mean than that the particle receives i
motion from Him who has Life in Himself and that it
indestructible?

Today this proposition has been most wonderfully co
firmed. Today we are certain that the atoms are "sel
moved" within, that they have been thus moving for hu
dreds of millions, perhaps for thousands of millions of yea
without any cessation, save in a few instable radio-acti
atoms which have been the means of revealing the intern
mechanism, and that nothing that we can do can alter th
motion which is as irresistible as the tides of the ocea
This power is from within and not from any outside sourc
The internal motions are on an infinitesimal scale, but pa
take of the character of infinitude which may be equal
manifested in the very great and the very small. The e
traordinary nature of this evidence of the truth of Swede

borg's doctrine of perpetual *influx* of energy from the Divine into the interiors of material particles, of the constitution of these particles through *motion,* and of the *vortical form* of this motion, can not be too strongly emphasized. As yet it has been only imperfectly grasped. Primitive man had an intuitive recognition of the voice of God in the tempest, but it was more difficult to accept the teaching of Jesus: "The very hairs of your head are all numbered." Yet the Divine Providence is in least things as well as in greatest.

Swedenborg's science is founded on God's government and recognizes that this is real, and not a mere metaphysical abstraction, or a mystic meaningless phrase. He says:

> That is called universal which is made up by all single things together, like a general thing existing from particulars. If therefore you take away the single things, what then is the universal but as something which is empty within, and so like a surface with nothing inside, or a complex containing nothing? If the Divine Providence were said to be a universal Government, and still nothing is governed by it, but only held in its connection, and the things belonging to government are conducted by others, can this be called a universal government? No king has such a government; for if any king were to allow his subjects to govern all things of his kingdom, he would no longer be a king but would only be called so; thus he would have the dignity of a name only, and not of any reality. Government cannot be predicated of such a king, still less universal government. What is called Providence in God is called prudence in a man. As universal prudence cannot be said to belong to a king, who has reserved but the name, in order that the kingdom may be called a kingdom and may thus be kept together, so there cannot be said to be a universal Providence if men from their own prudence provide all things. And so it is with the name of universal Providence and universal government when applied to nature, and meaning that God created the universe, and endowed nature with the power of producing all things from itself. In this case,

> what is universal Providence but a metaphysical term which, except as a term, is a nonentity? Moreover, among those who attribute to nature all that is produced, and to human prudence all that is done, and who still say with the lips that God created nature, there are many who think of the Divine Providence only as of an unmeaning word. But the real truth of the case is, that the Divine Providence is in the smallest particulars of nature severally, and in the smallest particulars of human Prudence severally, and that it is universal from them. (Angelic Wisdom Concerning the Divine Providence, n. 201.)

In the above specification of the primal particle (for although what is quoted refers to "the first or simple finite," yet the actives and passives derived from it and combined in the initial primal particle are essentially similar), the superficial motion resembles that of an Archimedes spiral, except that it is not in a plane but is inscribed on a spherical surface. From the use of the singular number in "the ecliptic," it appears that *the* ecliptic plane of the particle is supposed to pass through the intersection of the spiral with the equator. Otherwise there would be an indefinite number of ecliptic planes, all of them tangent to the polar circles. In order that the spires of the spiral shall be "circles of latitude" (as they are said to be) they must be at an infinitesimal distance apart, and in this case the polar cones are of infinitesimal aperture and the "ecliptic" coincides with the prime meridian. Such is not the form ascribed to the "elementary particles" of the vortex-ring sort, where the superficial spires are shown making angles of about 60° with the equator, which would require polar cones of 30° aperture. These approximate more nearly to the form which must be attributed to the electron. The *internal* motion in any case cannot follow the spiral of Archimedes, for this spiral has no limit; but the internal motion must have some such law as that of the sinusoid spiral, if the motion is to be reciprocating, as is specified. The description just quoted seems to be a complex of two different conceptions. It looks ahead to the vortex-ring which is eventually adopted for an elementary particle (also called the "first elementary particle," but which is entirely different from the primitive one shown in the above noted Figure 11.) The description, however, also lingers on the borders of one given in the *Minor Principia,* which would be appropriate for the primal particles if these are indeed spherical. This particle was supposed to have inward motion at *both* poles and was abandoned because it seemed to its author to involve the formation of a rigid central nucleus with final destruction of motion. Perhaps this abandonment was too hasty, for there would be a decided advantage to the primal element (certainly a greater degree of freedom) if its two poles were of the same sort. Conceive two rectilinear vortices of tremendous velocity of spin boring down to the center of the particle from opposite poles. The substantials which they bring meet at the center at a point where a relatively enormous energy of impact is developed, causing the substantials to disperse in all directions. If it is admitted that the dispersal is along paths which are sinusoid spirals inscribed on cones whose apices are at the center of the sphere, they bring up in circles on a spherical surface which is a region of congestion. The superficial substantials cannot return to the center by the way they came, because of the outgoing pressure of succeeding substantials; and therefore they are crowded towards the poles where the diminution of the orbital radii of the latitude circles gives such great angular momentum that the polar line-vortices are perpetually renewed. The motion originates from a center and returns to it; and the section of the stream of substantials, as well as its velocity, vary through a wide range. All that is necessary is that equal quantities of motion shall pass through any given stream-section in the unit of time. The particles thus formed should be exceedingly resistant, yet withal equally resilient. They are capable of being juxtaposed in long chains of like spin, that is, they readily form lines of magnetic force under the action of revolving electrons; and they readily lend themselves to the transmission of gravitational waves from the pulsating electrons. The lines of force in the aura tend to expand laterally, but to contract longitudinally, a property which renders these lines and their constructive particles of aura extremely favorable to the production of attractive forces. We may conclude that the electrons and the atoms are composite particles, formed from the aura and endowed with properties which rest upon those of the primordial medium.

The discontinuity of matter is a fact; but the universality or essential continuity of natural law is equally a fact. These two seemingly diverse conceptions must be capable of being fused into one consistent whole. That which will fuse them them is the perception of the relation between spirit and matter. One other fusion of conceptions pleads for recognition, namely, the grand scientific law of the conservation of energy must be united with that still grander conception of the immortality of the human soul. The two are counterparts, as Sir Oliver Lodge has emphasized in his Birmingham address. From a recognition of the unity of law in the two kingdoms,—the kingdom of nature, and the kingdom of human nature—will come the overthrow of many fallacies. Thus the knowledge that energy of a higher type, such as the thermal energy in a heated body, can not flow into a still hotter body, disposes of the allied fallacy that natural science can fathom spiritual truth. The reverse, or the comrehension of nature in a true schematic view which starts ith spirit and includes nature, is, however, feasible.

The particles of the aura, in Swedenborg's view, are eceptacles of energy from a spiritual source. They also erve as the medium for transmitting and transmuting this nergy into variously woven forms. The aura is a great eservoir of potential energy on which all nature can draw; ut when the derivatives cease to function, free energy liminishes, and the entropy increases, that is, the energy eturns into its universally diffused potential form.

Out of the aura, and formed by special groupings of its articles through rotation, issue the electrons—a new order f particles in the form of vortex-rings, whose beating is the eart-throb of the universe; for everywhere their pulsations ccur at absolutely the same instant and in identical phase, rinking in energy from an inexhaustible source. The atoms, n turn, receive their mass from the included revolving elec-rons, completing the vortex-atom trine.

We know that energy is indestructible, but can not tell what it is, or whence it is. "The wind bloweth where it listeth, and thou hearest the sound thereof, but canst not tell whence it cometh, and whither it goeth: So is every one that is born of the Spirit." (John's Gospel, III, 8). I must perforce use the language and analogies of the spiritual life, for what can be eternal, save the Divine? And where else can we find a source of power sufficient to sustain the activities of the universe and hold them together in *one* universal harmony, without clashing, with a unanimity and a universality of a stupendous law which never fails, which is the same everywhere to the remotest bounds of drifting star streams and through all the ages,—unless we turn to a most intimate Divine control which is the Inmost of nature?

The Divine which is in space without being of space, and in time without ever being confined by time, inflows an produces nature from moment to moment by a rhythmi imparting of energy with an absolute simultaneousness o phase in every part of our starry heavens, so that gravit acts to the remotest limits of the Galaxy almost instantaneously, because of the close conjunction of its energ with the timeless Spirit of the Universe. The finite see space as an immeasurable void. To the Divine Omnipotence, space is absolute plenum.

You may call this poetry, but it is good science also, fo from the hydro-dynamic analogy which Bjerknes showe in his pulsating drums, it is evident that expanding an contracting particles, whose surfaces have everywhere th same phase, must attract each other. If Planck's fundamental unit of time, 1.34×10^{-43} sec., is the pulsation perio of an electron, founded possibly on the rate of flow o energy in the underlying aurions, this is the standard o time for the universe, just as much as the Earth's histor is written "in the process of the suns"; and gravitatio (which toward the end of his life Swedenborg assigned t the aura, or "the purer ether, which is universal, and fro which is all gravity") is the pulling together of all part of a given galactic system of stars through the interactio of waves in the aura from pulsating particles. The fundamental energy of the gravitational fields of force of th atomic complex constitutes an intricate and gigantic pattern surpassing finite comprehension. In the meshes of thi pattern, the history of the universe is written, for its textur at any given instant depends on all that went before. "I is love that makes the world go round," and as love draw all hearts together, so Divine Love, inflowing as the Sourc of energy into least microcosmic hearts of infinitesima ture, draws the universe together and binds it into a whole. not this the origin of gravitation and its attraction?

We conclude from all that precedes that there is (1) a iversal atmosphere whose special function is *attraction,* ther gravitational or magnetic, and unification; and reembering that it is love that attracts and unites, this atosphere corresponds to that highest spiritual aura in which e the angels of love who are nearest to the Lord.

(2) And there is an intermediate whose special function emanation and which manifests itself in many ways: as e sunshine and the lightning's flash; or as the inner forative motion which evolves matter; as the electric wave f the wireless telegraph; as the signature of innumerable arieties of atomic and molecular vibration seen in the emental spectra; and perhaps as the physical basis of lepathic thought. This intermediate is the *separating and iversifying element.* Therefore it lends itself to intricate lamentary forms, as in certain modes of electric discharge. herefore the electronic "atmospheres" are discrete. Thus ey correspond spiritually to the things of the intellect hich produce differences of opinion, individualizing and ariegating thought in endless diversities of belief and peretual complexities. This intermediate diversifying element n nature therefore represents in ultimates the formative r distinguishing principle—the Divine Proceeding, the ogos which comes forth from the Mouth of God, the Vord without Whom "was not anything made that hath een made." Light ineffable. Light creative. In the beinning God said: "Let there be light."

(3) And finally, from a conjunction of these two eleentaries, or higher atmospheres, there results *matter* which ometimes exists as an atmospheric form—the lowest atmoshere—as in the entire volume of the sun and the outer

envelopes of the planets, and sometimes is condensed into a liquid or a solid where reside properties of mass, momentum and kinetic energy, both that of the molecules, or heat and the energy of missiles, or of machinery, or of worlds All that we see in nature is formed out of the one universa atmosphere from which are generated subordinate structures in trinal order.

CHAPTER III.

SWEDENBORG'S "BULLULAR HYPOTHESIS"

SOME of my readers may have seen Millais' picture of a beautiful curly-headed child blowing bubbles. The artist has caught him just as he has thrown off a bubble and, with uplifted face, is watching it soar away. Anxious mothers will notice that Charlie has his best clothes on and will expostulate that the lad will get all slopped up with soap and water. The artist has not thought of this. He wants to suggest the pursuit of ideals, which are beautiful things, and has not considered possible objections and difficulties. Nevertheless, stern mother experience is continually holding us up in our quest of ideals and compelling us to come back to prosaic and practicable things.

Swedenborg, in his early "bullular hypothesis,"* is careful to warn us that his conception is speculative and that it must stand or fall at the decision of experience. The speculation is primarily founded on the following fact: If a given volume of liquid water be heated to the boiling point, it may all be boiled away and expanded into a mass of vapor which occupies 1695 times as much room as the original liquid. Swedenborg's suggestion is that the liquid particles are little spheres, packed with still smaller spherules of another sort; and that through the agency of heat, some of the central spherules become active and push out the circumferential layers of spherules until a bubble is formed with but a single outer layer of limiting or finiting spherules.

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* "A hypothesis of the Figure and different magnitudes of Elementary Particles." Miscellaneous Observations connected with the Physical Sciences. Emanuel Swedenborg. Translated by Charles Edward Strutt; Part III, pages 81-108; London, 1847. Original published in Leipzig, 1721.

The particle, as thus expanded, is specifically lighter than before and will rise up and soar away. The conception is plausible and he proceeds to extend it so as to cover other orders of still finer particles, all of which are assumed to be constructed on precisely the same plan. He specifies these divers orders as follows: "There are particles of air, particles of ether, particles of light and particles in which the magnetic power consists." (*Op. cit.*, p. 84.) Here light is said to be made up of "particles," but these are distinguished from particles of ether. (In the author's *Principia*, this distinction is not made.)

He supposes that "air, ether, light, etc., consist of merely bullular particles, only differing in size; that is, that their diameters differ in the geometrical ratio of 30; thus, that the diameter of air being 1, that of ether will be 1/30, that of light 1/900, and so on" (page 85). The existence of such particles and the differences in their dimensions is said to be "only an assumption, which must be corrected by experiments"; and the examination is said to be "only of the most general kind."

He chooses the spherical form, he says, because it is the "simplest possible" (page 86). To form the spherical boundary he assumes "central motion," or more exactly motion *from* a center, since, according to him, "the infinity of points constituting the surface, must have a force from the center to the circumference, which is of course bullular. . . . The first motion must clearly arise from the Supreme Mover, from the Supreme Life, from God, the Creator of all things, Who by means of His primeval motion, . . . impressed upon His world of nature the identical principle that governs in geometry" (page 86).

The idea given in the *Principia* may be regarded as a revision and further statement of this initial conception, and includes that of innumerable fluent particles of energy (*conatus*) proceeding from a center along spiral trajectories whose law compels them to end in a minute circular spin which limits or finites the motion. (See F. W. Very's figure in his notes to the new English edition of the *Principia.*) The energy-particles must be regarded as expanding in proportion to their radial position until they are crowded together and bring up in the surface, and they consequently produce an infinitely resistant spherical surface in extremely rapid rotation, which can in no wise be broken or changed. Osborn Reynolds imagined infinitely resistant spherical particles, but his lacked structure, or any rational conception of their mode of origin, and therefore they remain a mere dogmatic assertion without adequate cause.

Swedenborg's primal medium, formed out of these spheres filled with life from a higher source, quiver with energy from their incessant collision. According to the experimental evidence which has been gathered in the preceding chapter, relating to the constancy of dimensions of fundamental entities, it is demonstrated that the particles themselves can not be compressed to more than a minute extent, though they may be distorted; but as they are not in more than momentary contact, they can be crowded together to a slight extent by distortion at local surfaces of particles of the next order. The primal particles, once formed, can not be destroyed except by a Divine withdrawal of energy, that is, they are of infinite duration, as well as infinite strength.* They issue in the fulness of their power straight from the Hand of God. This, at least, seems to me a succinct account of the primal form which Swedenborg was trying to visualize.

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* It is known that if electrons or atoms could be made to advance with the velocity of light, their masses would become infinitely great. All of the internal motions and properties of Swedenborg's primal particles are of the infinite sort. Their circumferential velocity should be something like 10^{36} cm/sec.

In addition to motion from a *center* which is evidently regarded as a source of motion as well as of energy, and this motion as being wholly internal, mention is also made of "progressive" and "vibratory" motions appertaining to these bullular particles (page 86), and by these external motions further particles of composite orders can be woven. Note that from this *center* which is itself without space, though it may be connected with a *super* space of more than three dimensions in a world of pure spirit, nature may be said to originate.

The finer particles of the successive orders are supposed to progress or flow freely through the interstices between the coarser composite particles (as light flows through or between the atomic structures of a glass plate, or magnetism from the iron core of the Earth through the outer rocky layers); and each particle in the successive orders is supposed to have three sorts of motion: Axial (*i. e.*, rotary), progressive (*i. e.*, onward in a given trajectory), and vibratory (which may be either pulsatory or oscillatory, though which of the two is meant is not distinctly specified here).* The different orders may obviously fill the same volume, the more composite orders consisting of and being circumscribed by the finer ones.

The subject of pressure is then reached and these further assertions are made: "1. It is the nature of every element o press equally on all sides. 2. Therefore, when one elenent acts on the bullae of another, the former presses from vithout towards the center of the bulla, but the latter from vithin, from the center to the periphery; and an equilibrium s produced. 3. Hence the particle of one element is mainained in its continuity by those of another as by a chain onstantly surrounding it. 4. Besides, it may be demontrated geometrically, that the smaller bullae are stronger nd less liable to disruption than the larger."

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* Swedenborg is not always consistent in his use of terms. Thus in Principia, Part III, Chap. V, referring to the motions of a planet, "progressive" means precessional, that is, a special case of oscillatory or vibratory motion, and the onward motion of orbital revolution is not called progressive, but "local." Elsewhere he uses "ecliptic" motion in the sense of a transverse component to axial rotation.

This looks reasonable enough, but if we appeal to analogy rom experiment, the argument is not supported by soapubbles which owe their existence to surface tension of a iquid pellicle and not to pressure from surrounding air articles. The latter are not absent, but they have no ausal function.

Swedenborg proceeds as follows: The three forms of notion proper to the particles are described as "progressive, xillary, and tremulatory" (page 87), where a new species f motion around an axis is introduced and nothing is said bout the supposed "central" motion. The latter is preumably taken for granted as constitutional or peculiar to ne primal particles, and is omitted from further mention.

The next section treats of "The great power and intense notion of the smaller Bullular Particles especially." It is ssumed here that the *vapor* of water is composed of bubbles hich "remain entire, and rise without disruption into the igher regions of the atmosphere, although the air presses pon them with great force on every side." Also water arefied into vapor by fire has force enough to break a glass, r even a stronger vessel, and as steam "will set an entire achine in motion, for instance, a wheel, as has been ascerined both in large and small engines" (page 88).

He apparently supposes that air particles are very much smaller than water-vapor particles,* whereas we now know that equal numbers of molecules of either substance fill equa volumes, and that the individual molecules cannot diffe much in size.

He thinks that the surfaces of the larger bubbles will b more easily bent inwards than those of the smaller ones and says: "We find also by experience, that a large glas globe is more readily broken than a small globe of the sam thickness" (page 89). He might have added that a fin froth of water bubbles is more persistent than larger bubble and every child knows that the difficulty in preserving soap bubble increases very rapidly with its enlargemen He says that "degrees of consistency are reciprocally a the diameters." This is surely an overestimate. It is muc more than twice as difficult to make a bubble of twice th size of a given sample; and after a certain limit, dependin on the tensile strength of the liquid, has been exceeded, th expansion of the bubble cannot be pushed farther. Th point is reached when, from optical tests (Newton's colo of thin films), we conclude that the liquid pellicle has bee reduced to a single layer of molecules. Any further ex pansion pushes the liquid molecules beyond the limits c their spheres of adhesive attraction and breaks the film.

Swedenborg attributes the greater strength of sma bubbles to the greater rapidity of their central motion. I soap bubbles the air-pressure inside the bubble increas as the radius diminishes, but this we find is due to tl increase in the difference of surface tension between tl nvex and concave surfaces of the film, and this gets rger as the curvature increases. That the strength of the ap bubble is wholly a property of its surface film is shown the fact that the strength and endurance of the bubble n be greatly increased by modifying the liquid of which is made, as, for example, by adding sugar to the soapsuds. he strength of the bubble has nothing to do with any larger smaller motion of the enclosed air, but the strength of e bubble and the condition of the "central" air are both termined by the properties of the film. The supposed duction from the bullular hypothesis is decidedly not nfirmed.

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* Mention may be made of the possibility that by water-vap particles may have been meant mist particles to which the fo of bubbles has been attributed by several meteorologis (Kaemtz, for example.) But the context here distinctly impli that the author is talking about the invisible particles of stea

"Tremulatory motion," according to Swedenborg, "is most pid in the smaller bullae, and is as the squares of the ameters" (page 89). This is evidently a mistake for *verse* squares. On this score he concludes that the vibrations of light must be immensely more rapid than those of r. The ratio of the frequency of vibration of an electron that of an atom should be about $10^{10} : 1$ by this rule which not a bad guess.

The next point, however, is not so happily taken. Swedenorg affirms that air particles are diminished in size by creased pressure. This is no longer admitted, at least ny diminution in the size of an atom by pressure must be ery small. The atom is practically incompressible by rdinary concussions and is kept so by the enormous velocity f its rotation which cannot be changed by anything that e can do to it.* The kinetic theory of gases assigns the ermal properties, the pressure, and the expansive force f a gas with acquisition of heat, to the energy of local progressive motion of its particles. The mean velocity o the particles increases as the temperature rises, and thus th momenta of the particles become greater, collisions ar more frequent, the pressure, or force resulting from im pact of the bombarding molecules, increases and, unless cor fined by rigid walls, the gas expands. The mean free path of the molecules in an unconfined gas vary, but not thei individual dimensions. Here we have a totally differen explanation of the expansion of a gas from the one tha Swedenborg gives. The modern kinetic theory has bee repeatedly assailed, but has triumphantly met every ob jection that has been urged against it and is supported o all sides by the results of experience. It explains the inter penetration and rapid diffusion of gases into each othe much better than the hypothesis that the bubble-like particle are everywhere expanded into mutual contact. It has re cently had a vivid confirmation in the evidence of the spin thariscope, where atoms of helium emitted from radiur strike a surface of zinc sulphide which they cause to phos phoresce momentarily. The luminosity spreads over a sur face much larger than the dimensions of an atom, becaus the shock of the collision is distributed through a grea number of molecules of the solid zinc sulphide, but still remains a comparatively tiny spot of light, requiring th use of a lens to bring out the full beauty of the scene, whic resembles one of the most brilliant star clusters of the Milk Way as seen through a great telescope, but with the littl points of light flashing and scintillating in endless variety It is evident that the free helium atoms do not expand int mutual contact in a vacuum, since the phenomenon is no altered by any change of pressure. During the long ex tended processes of their initial formation, atoms underg repeated and very extended condensations. But onc formed, their atomic volumes no longer vary more than a very little.

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* The intense pressures exerted when atoms combine chemcally may, indeed, produce a slight diminution of the atomic olume, but this condensation is of very limited amount.

Fluidity of water particles is attributed by Swedenborg to "some very subtle igneous matter of great mobility interfluent between them" (page 95); but this is quite unnecessary. Fluidity of water is due to a haphazard distribution of molecular poles which do not become arranged in parallel positions so as to interlock until their thermal motion subsides and crystallization sets in. He imagines that the air bubbles seen in ice (which we now know are due to expulsion of dissolved air as the water freezes) are this peculiar "subtle matter." It is all a misapprehension from lack of knowledge.

Finally he says: "Unless the mechanism of bullular particles be identical with that of elementary particles, the whole bullular hypothesis must fall to the ground" (page 96); and thus, according to its author's further development and modification of his theory in the *Principia*, where a different form is attributed to the fully developed first elementary particle, the hypothesis had already more or less fallen before Swedenborg had finished his studies.

In the section on "The notion of a Central Fire" (pages 100-103) he thinks that hot bodies must be much heavier than cold. But the Sun's material is now known to be specifically lighter than the Earth's, although the sun is enormously the hotter of the two. If we could assume that Swedenborg intended to say that the more *massive* bodies are the hotter ones, then there is reason to surmise that possibly this may be so. At least, the more massive stars are of more than average temperature on the whole; and the major planets are interiorly hotter than the terrestrial ones.

We might go on pointing out other discrepancies between hypothesis and observation, but this is probably enough. Some flaws have been found, as was to be anticipated in comparing the knowledges of a remote epoch with the riches which have been acquired since then.

Shall we say therefore that there is no truth whatsoever in any bullular hypothesis? I do not think so, and in fact I have ventured to suggest * that an atom probably consists of a succession of paired concentric spherical shells of positive and negative electrons and in this respect may be likened to a composite bubble; but the electrons are not in mutual contact like the spherules which form the surface of one of Swedenborg's bubbles. On the contrary, the electrons in the atom are relatively far apart and are maintained in positions of equilibrium by electrical forces acting in connection with the centrifugal forces of extremely rapid revolution. The positions of a few electrons which possess special properties, may also depend upon magnetic forces.

In like manner the electrons themselves are probably vortex-rings in the universal aura, and are identical with the vortex-particles of the first element in Swedenborg's *Principia*; but in this case they are not spherical particles and their limiting surfaces are not formed of particles which differ from the central ones in anything save relative velocity, since a limiting surface of revolution arises here from the fact that the rotary velocity † of the electron

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* "The Luminiferous Ether," page 18.

† That the electrons in a cathode ray are rotating all in the same direction and are advancing in the direction of their indrawing poles appears probable. The discovery by Crookes that parallel cathode streams advancing in the same direction repel each other is explained on this supposition, since the adjacent surfaces of particles which advance side by side, must have contrary transverse motions. This being so, cathode streams which move in opposite directions should attract each other, and they are found to do so.

(which increases outwardly) can not be pushed beyond that of light without exceeding the breaking strength of the aura.

It remains to be seen whether, after rejecting the objectionable features, it may not be possible to devise something different from Swedenborg's original bullular hypothesis which will retain anything that it may have of advantage and still satisfy the greatly extended requirements of new facts which have accumulated since his day. I therefore pass to some aspects of modern atomic theory which are of interest for comparison.

CHAPTER IV.

SWEDENBORG'S HYPOTHESIS OF ELEMENTARY VORTEX-PARTICLES AND MODERN ATOMIC THEORY

SIR J. J. THOMSON proposed the hypothesis that an atom is a sphere of positive electricity, within which certain negative electrons, or least particles of negative electricity, are arranged in Mayer patterns. But he did not attempt to define what positive electricity is, and gave no suggestion of a bubble form. The conception was mainly an affair of abstract mathematical symbols and ignored the need of a physical basis. I have tried to supply these deficiencies and have arrived* at an atomic form which resembles Swedenborg's particle in that spherical shells of lesser discrete particles (the electrons), forming a complex, are predicated. The plan has the very great advantages that it explains the difference between positive and negative electricity in accordance with their experimental behavior, and that it also offers an explanation of the thermal properties of the chemical elements and of the origin of continuous and line spectra.

Swedenborg's vortex-particle (as may be noted from the quotation in Chap. II, page 81) presupposes an equatorial rotation which is much more rapid than the meridional or ecliptic" rotation, the two being components of a single esultant motion. The electron appears to be such a par-icle. In Lord Kelvin's "vortex-atom," the relations were eversed, or rather the equatorial rotation was considered egligible. This form exists in an air ring or smoke ring, ut is not the sort of motion which generates the atoms of he chemist. In his early researches on vortex-motion, J. J. 'homson imagined intertwined vortex-rings. The intricate notions of these ideal forms make an exceedingly inter-sting subject for mathematical study, but they seem better dapted to the conditions of the world of spirit than to hose of a terrestrial atmosphere. The idea was abandoned y its author for the one just referred to. The only atom vhich is now considered is the one whose rotation is quatorial.

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* See "The Luminiferous Ether" which has already been cited.

There is an important passage in the *Principia* which 'ormulates a leading principle in the propagation of ele-nental motion:

> The motion among the elementary particles not only is pro-agated and extended according to the form and natural arrange-nent of the parts, but it also terminates in them. Because among he elementary particles, every part, as we have before stated, ontributes its share to the motion and form of motion in the olume; it follows that the volume of the particles can not be noved, or determine the form of its motion, in any other way han the individual parts allow. Hence the motion of the volume nust be perfectly in agreement with the motion and form of he parts. If the elementary parts were exactly spherical, the notion would spread itself around into the form of a sphere, nd describe perpetual circumferences equidistant from the enter. (Principia, Part II, Chap. I, n. 3).

It is on these grounds that Swedenborg concluded that the particles of the ether must be spherical, because light is propagated in spherical waves. Since gravitation in like manner acts spherically, the inference on the same principl is that the universal atmosphere is also made up of spherica particles, and Swedenborg started with this shape for hi primal particles, but afterwards modified their structure t that of a vortex-ring (as shown in Chap. II), evidentl because the supposed flow around a magnet was assume to be vortical, so that he concluded in favor of a particl which could pass from the spherical to the vortical form If magnetism consists in an arrangement of particles i filamentary spinning strands (probably combined with general rotary flow, for which see Chap. VI, Section E the synthetic form described in the previous chapter supplies the needs of either gravitational or magnetic activit equally well. Gravitation is probably produced by spherica waves of alternate rarefaction and condensation in a medium composed of spherical particles. The electrons ma be ring-vortices, but they are always encompassed by spherical envelopes of ether so that the waves which issue from the combination are spherical. The molecules are not sphere but consist of groups of assorted spherical atoms, and thes no doubt determine the spherical form of the sound wave Thus the evidence favors atmospheres whose ultimate particles are spherical, and to this extent we are prepared t admit the possibility of bullular particles.

The "astronomical" atom of Bohr and others, consistin of electrons revolving in an orbital plane—an assumptio which is much in vogue among physicists at the presen time—will have to oscillate its plane through 180° to giv the effect of a sphere. I am not aware that anybody ha advocated this, and the plan remains a two-dimensiona conception which is properly rejected by the chemists.

E. R. Lyon (Physical Review, Ser. 2, Vol. III, page 23 1914) has investigated the chemical properties of the atom rranged on Sir J. J. Thomson's plan. According to Lyon, ie central group of a Mayer pattern is the one most easily isplaced. Consequently, the loss or gain of one electron ffects the central group, and not the surrounding rings f the pattern, which are supposed to revolve more rapidly id to have a gyrostatic stability. The few central elec-rons are supposed to move very little and to be kept in lace ordinarily by electric repulsion of the symmetrically laced outer electrons, or else by a magnetic control. A omparatively slight distortion of an outer ring destroys s symmetry and starts a central electron from its place, r possibly ejects it from the system; whereas the rapidly evolving outer electrons do not remain long in unstable ositions and are preserved. The chief virtue of the plan that it gives a ready explanation of valency. But the etails of this plan are of doubtful validity. If there are evolutions, planetary analogies favor the opposite distribu-on of velocities, that is, the central revolutions should e the more rapid. Langmuir has a plan of an atom, which e shall describe more at length presently, with a different rrangement which explains a large number of chemical roperties, including valency, and finds that the central roup of electrons is the most stable of all. Its vibration also the most rapid of all.

Still a different form of atom was suggested by the riter in 1902, from the phenomena of the nebulosity round *Nova Persei,* which "favor the supposition that ie atoms are formed by various arrangements of numer-us ions of perhaps only three species." (See American ournal of Science, Vol. XVI, page 57, July, 1903). This tom was supposed to be composed of three kinds of sub-toms with atomic weights of 1, 2, and 4 respectively, the rst and last attributed to hydrogen and helium. Not long afterwards, J. J. Thomson discovered that the positive ray of electricity produced from various gases are of thre sorts with precisely the preceding ratio of the masses determined by their deflections in a magnetic field. I following up the conception, I noted in my article on th *Principia* in the New-Church Review for July, 1913, th Swedenborg represented an ether particle in a state condensation (which according to him will serve equall well for an air particle, since they are not supposed b him to differ as to plan) as containing spherical *bullae* smaller size within the larger sphere, and I said (*op. ci* page 412):

"Now the denser radio-active atoms are found to underg progressive simplification through the expulsion of heliu atoms at high velocities. If it is permissible to suppose th the light helium atoms are of relatively small size compare with heavy atoms, and that they exist already formed withi the larger atoms, Swedenborg's internal *bullae* may helium."

It is known, however, that free helium atoms have atom volumes nearly twice as great as that of uranium, althoug the latter is sixty times as heavy as the helium atom. Henc if inner helium atoms exist already formed within t heavier atom, they must be extraordinarily condensed a can have little resemblance to their free congeners.

At the twenty-second meeting of the American Astr nomical Society in 1918, I elaborated the conception a suggested that the hydrogen, nebulium and helium of t gaseous nebulæ are the three constituent substances out which all of the denser atoms are being formed in the regions of synthetic processes, to be eventually incorporat into stellar nuclei; and that thus the gaseous nebulæ a regions of space where the wastage of energy from atom disintegration in solar centers is repaired. The proposition involves the recognition of a *Third Law of Thermodynamics* which states that in the nebular regions the wastage of stellar substance and the increase of entropy ceases, because here there is a reversal of the "dissipation of energy" which completes a full round of the atomic cycle (as originally suggested in my papers: "A Cosmic Cycle," American Journal of Science, Vol. XIII, 1902; also Ciel et Terre, 23 Année, Nos. 1, 3, 5, 6, 9, 10; and "What Becomes of the Light of the Stars?" Popular Science Monthly for March, 1913). In the paper on "The Wasting of Stellar Substance," which appears in the Italian journal, Scientia, Vol. XXVII, pages 265-274, 1920, I do not insist on the continuous identity of the constituent subatoms in the complex, but have recognized that the components are more likely to merge and flow together into a common sphere.

Another form of the hypothesis of subatoms was given in 1915 by Harkins and Wilson in the Journal of the American Chemical Society, Vol. 37, pages 1367-1396. These authors point to certain "remarkable relations in the atomic weights, such as exist in one of the triads of Dobereiner," where lithium and sodium, and sodium and potassium are found to differ in atomic weight by almost precisely sixteen units, or four times the atomic weight of helium. These authors therefore propose the hypothesis that the heavier atoms are formed out of hydrogen and helium.

In the same journal for February, 1916, Harkins and Hall give interesting details of the chemical properties and transformation of the radioactive elements, all of which can be accounted for by the loss either of a helium atom or of an electron. The suggestive composition of the gaseous nebulæ to which I have alluded, the 1 : 2 : 4 ratio in pressure-shifts of spectral lines discovered by Humphreys, the exhibition of the same ratio in the emanation from *Nova Persei* and in the behavior of positive rays in a vacuum-tube, are not utilized in this explanation; and where isotopes, such as neon and meta neon, differ in atomic weight by two units, this is attributed to gain or loss of *two* hydrogen atoms, although other similar transformations involve the gain or loss of only a single helium atom, suggesting that the change of two units is produced by an atom of that weight which has not yet been isolated chemically. That such an atom exists in the gaseous nebulæ is extremely probable.

The hypothesis of subatoms must now be subjected to further tests. Bragg finds by the X-ray analysis that in crystalline solids there is regular arrangement of lines of various atoms in a space-lattice, but that the identity of individual molecules, such as exist in the liquid or gaseous states, is completely lost in the solid (at least in the halides and similar substance which served in his analysis). The X-ray analysis reveals the presence of the special electrons in the atom which make up the Moseley number, but does not show any signs of subatoms. For example, according to the hypothesis of Harkins and Hall, the atom of iron (atomic weight = 56) should consist of fourteen subatoms of helium; and as each helium atom has two significant electrons, the iron atom should contain 28 significant electrons, whereas its Moseley number is 26, and this, as we shall see (cf. page 126), is confirmed by Hull's X-ray analysis. We must conclude that, whatever component atoms may have been concerned in the evolution of complex atoms, such components have been submerged in the resulting atom and have lost their identity.

It may be noted in passing, that Swedenborg was the first to suggest the existence of space-lattices in crystals, though the suggestion was marred by bizarre notions concerning sharp-pointed particles in acids, etc., inherited from the alchemists.

These historicals bring us to a much more extensive change in atomic theory involving an explanation of the gravitational properties of the atoms, properties which are virtually ignored in the current electrical hypotheses of atomic structure.

Professor Reginald A. Fessenden, in 1900, advanced the theory that matter is wholly electrical and Professor (now Sir) J. J. Thomson in describing Kaufmann's experiment concluded that the observed increase of mass at high speeds favors this view (see his "Conduction of Electricity Through Gases," page 655); but subsequently he seems to have abandoned the supposition and to have acquiesced in Sir Ernest Rutherford's view that the positive nucleus of an atom is much smaller than a negative electron and that the electrons are too few in number to account for the mass of an atom. Rutherford was led to this doctrine because he found that alpha and beta particles from radium pass through atoms without suffering reflection except when the approach is within an excessively minute distance from the atom's geometrical center which is assumed to be the radius of the positive electron. This plan of the atom has nothing in common with Swedenborg's bullular hypothesis. It is also rejected by the chemists because their science calls for arrangements in tridimensional space with fairly equable distribution of electrons in every direction not found in the physicist's atom. Moreover, the supposed nucleus, or "proton," is little better than a metaphysical abstraction.

Now according to Fessenden's argument, it is not possible to have any greater concentration of electricity than that of the negative electron. I have therefore sought for some other interpretation of Rutherford's experiment and find it in the analogy of the interference of light. The particles of light are relatively far apart. If interference depended on direct collision of particles, very few of them would meet and only a minute fraction of the light could become polarized. But there is no difficulty in obtaining complete polarization of light, and therefore polarization and interference cannot consist in collision of light-particles, but must arise from the interaction of extensive alternating magnetic fields in the general aura which accompany the electric oscillations of the ether-particles, the whole constituting a periodic electromagnetic, or wave-motion. Guided by this analogy we may conclude that atoms are very open structures, that there may be a certain amount of interpenetration of atoms without destruction of their constituent motions, and that a rather precise superposing of the extended magnetic structures between the electrons is needed to produce effective reflection, as in Rutherford's experiment.

Swedenborg believed that there could be interpenetration of particles, even without interference where the particles are of widely different orders. Formerly this was not admitted by the accepted scientific theorists. Atoms were imagined to be like marbles. They could be brought into external contact, but no further. Therefore "impenetrability" was supposed to be one of the essential properties of closely packed atoms. Today this conception is abandoned and a view which, in this respect, is in essential harmony with Swedenborg's is adopted. Beta particles from radium will pass through a considerable thickness of solid lead. Alpha particles, which are helium atoms, are shot off from radium and other radioactive substances at such speeds that they pass directly through many thousands of atoms before their velocity is so much reduced as to make them incapable of ionizing gases. In fact we have here a very vivid embodiment of what Swedenborg calls an active, except that the motion of the free helium atoms s rectilinear and temporary, whereas Swedenborg is decribing the perpetually regenerated circular internal motion within the radioactive atom before the tangential transformation.

In the initial definition an active is said to describe a surface and the form of this surface is attributed to an nherent tendency to curvilinear motion. Thus we read: “In the surface of the active, there is no point which can be truly called substantial, except the one where the substantial in motion is itself present. Nevertheless this entity s most perfectly active, and also endowed with a considerable power of acting upon the nearest finites” (*Principia,* Part I, Chapter V, n. 9-10). “Though the entire surface consists only of one point or substantial, yet by motion it s always, as it were, present in every imaginary point of ts surface; and hence every point of this surface is acting, but only at different times” (*Ibid.,* n. 11). The active is said to have “no local motion . . . except in a series” (*Ibid.,* n. 12). Nevertheless, the form of motion is the same in both: “This active arises from the same force and cause from which arose its coeval or coexisting finite. The power of the substantial to pass into gyration, arises, as we have frequently said, from the internal force or motion of the points. It is from the same cause also, that several points pressing upon each other by mutual contact, give rise to a certain new finite. For one substantial tends to a periphery similar to the periphery of this active; so do a second, a third, and innumerable contiguous ones; if, therefore, they all tend at once to the same periphery, if also one is contiguous to the other, then ought all collectively, in consequence of this motion, to flow together into such an arrange ment" (*Ibid.*, n. 23).

This innate tendency to a special composite spiral motio and its form, for aught we know to the contrary, may indee exist within the primal particles; but it does not exten to the first and second elementaries in their free state; fo both electrons and helium atoms, when liberated from thei associations, are radioactively emitted in rectilinear trajec tories and show no trace of any curvilinear tendency a long as they continue in free local motion, uninfluenced b a magnetic field.*

Moreover, as regards the electronic movements withi the atom, the motions are in circular orbits and are not mere repetition of vortex-ring motion. Besides this, bot positive and negative electrons are in free local motion an do not press upon one another within the atom, that is, the agree with the definition of actives in this respect; thoug Swedenborg's statement that every composite must consis of both actives and passives in consociation is fulfilled i a way; because, except as consociated with the active nega tive electrons, positive electrons are always attached t positive ions and are therefore relatively sluggish.† The move at much lower speed in the positive rays of th vacuum-tube as compared with the cathode rays; and eve then the positive electrons do not move by their own sol activity, but have to be carried as appurtenances of positiv ions. The "passives" are such, however, not because the are devoid of motion, but because their motion is restraine and thus they in turn can serve to limit or define a mor active motion. The passives are the "conservative" element and prevent the "radicals" from speeding up things to their destruction; and yet even the conservative element moves, though in its own way.

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* A partial exception is noted on page 25.

† In explanation of this, see the suggestion on page 130 tha positively electrified bodies are those which have superficia electrons so attached that their outflowing poles are presente outwardly.

Without abandoning anything that is essential in my plan of an atom, it would be possible to annex to it such structures, or details, as have been assumed by Barkla, Bohr, Moseley, Parson, Lewis, Langmuir, and others, for the explanation of valency, line-spectra, etc. All of these schemes possess merit in one way or another, although they are attended also by difficulties, as I shall show. Further investigation will be needed to decide between some of these rival claims. Bohr, for example, has devised a sort of "astronomical" atom in which negative electrons revolve in orbits around an excessively minute, central, positive electron which is the source of the central retaining force. The giving of Rydberg's fundamental frequency-number for linear series in the spectra of the elements with precision by Bohr's theory, is such an extraordinary feat, that it must be accepted as at least a partial truth. Yet the theory utterly ignores well recognized chemical and gravitational facts, and must be reinterpreted with extensive alterations, before it can serve as a component of the final complete atomic theory.

Parson attributes chemical valency to certain attachments to the atom which he calls magnetons. These are not defined explicitly, but since they are assumed to be revolving in rings having a thickness of one electron and with speeds approaching that of light, the revolution being accomplished in orbits whose radii are about one-tenth of the atom's radius, it would appear that orbital revolutions of electrons are contemplated, and these alone could give the requisite magnetic properties according to the theories now accepted.

But since a single electron thus revolving would radiate very rapidly, according to Sir J. J. Thomson, each ring in order to be stable must consist of numerous electrons, whereas the electrification of a chemical ion of unit valency is precisely that of a single electron.* The scheme would also give a multipolar atom, which is conceivable, though differing from the analogy of the ordinary magnet. We might, however, liken the nodal points of the outer, or valent, electrons in Parson's atom to the solar spots which possess a local magnetic polarity, but on a smaller scale than the general magnetic polarity of the entire solar sphere. The valent electrons might also be compared with terrestrial cyclones of which eight continually circulate in middle latitudes around the Antarctic pole and a variable number around the Arctic pole. In a rude way this is twice the number of the full valent complement.

The difficulty found by Thomson in regard to the instability of a *single* revolving electron may be obviated by having inner concentric shells of oppositely revolving electrons which give to the atom a powerful internal magnetic structure without necessitating an equivalent external field.

Parson constructed a model of an atom on an electric plan, with which he tried some experiments. It consisted of a central coil of wire (Figure 1), around which were grouped eight small solenoids, arranged at the corners of a cube and so suspended that they were capable of rocking independently about diameters transverse to the radius of the atomic model, or of swiveling around this radius. When

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* Bohr's hydrogen atom also is supposed by him to have a single revolving electron, and thus he ignores the dynamical difficulty urged by Thomson who, however, has not considered the possibility of meeting it by means of Swedenborg's hypothesis of a vortex-particle interiorly "self-moved." We may conclude that a vortical electron can thus continuously revolve without dissipating energy.

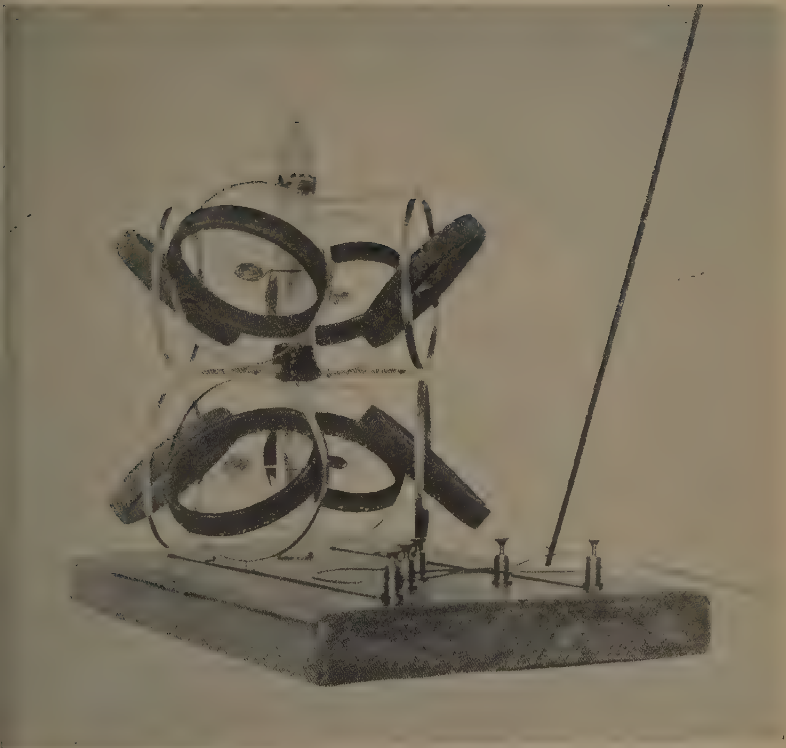

Figure 1.

oth central coil and solenoids were connected with a source f electric current, the solenoids, which represented magetons, assumed positions of equilibrium under the magnetic ontrol.

The plan which I suggest does not require such a strong entral magnetic field to control a few magnetons. Figure shows a small detail of the structure. Let $a\ b$ consist of portion of one row of electrons, forming part of an inner pherical shell. Let them revolve in the direction of the rrow and rotate as shown by the little transverse arrows. hey will constitute an element of circular electric current ith positive magnetic field (that of a north-seeking pole) urned away from the observer. Concentric with this row s the row $c\ d$ of the next outer shell with all directions eversed. The two will be magnetically neutral externally ut, between the strands, a magneton (m), revolving in a ny circular orbit with revolution and electronic rotation s shown, being the same as that of the inner shell, will be lectrodynamically attracted but electrostatically repelled y $a\ b$ when at m' and by $c\ d$ when at m'', by the usual rule or parallel streams. Consequently, it will tend to remain idway between the shells and its position in the atom will e determined by the combined action of the other superumeraries, which, if likewise constituting magnetons and istributed as in the iron atom, mutually reënforce their eparate magnetic actions; but in most atoms the arrangeent of the supernumeraries is such as to annul the magetism (either as a whole or in part). Most atoms are iamagnetic. If the electron were to cease revolving, it ould no longer be a magneton but would still have polarity f an electrostatic sort.

Langmuir (Science for June 18, 1920) finds from the onizing potential of helium, that the pair of innermost electrons which give it its Moseley number, cannot be revolving in a circular orbit, as Bohr supposes, but mus oscillate along arcs of eccentric circles through 77° 58′ o either side of their mean positions. By mutual repulsio at their nearest approach, the motion of the electrons i reversed.

Pairs of congruously revolving but oppositely phase (and therefore magnetically attracting) electrons, such a the four pairs which form a cube in an atomic sheath o zero valency, can have radiant stability. Parson's model to which we shall return, does not necessarily postulate parallelism of orbits needed for the absence of radiation, no does it nor any other scheme of a small gathering of electrons provide an explanation of the atomic mass which i far greater than that of either the valent electrons or o those which constitute the Moseley number. This ver important omission is supplied in the plan of paired spherical shells of positive and negative mass-giving electron whose function is wholly distinct from that of the supernumeraries.

Whether a single electron revolving in a circular orbi can be treated as if its mass were distributed all aroun the ring is perhaps an open question. Parson evades it an speaks of a ring equivalent to one electron, without explaining how such a thing can be produced.

There are other puzzling questions: Metallic wires, conveying electric currents which have the same direction, attract each other. Here, seemingly, the electrostatic effe is smaller than the electrodynamic. But similarly directe streams of electrons in cathode rays are mutually repelle and the electrostatic repulsion prevails. The explanatio is probably this: The electrons in the cathode rays do hav an electrostatic repulsion which is greater than their electro ynamic attraction at speeds less than that of light. But 1 the wires, the electrons are not so free to move. The iteral pressure which they exert, as well as the pressure of nward propagation, which does not force the wire to move ngthwise, are all converted into heat. It is the lines of iagnetic force between the wires which bring them into arallelism. These lines tend to contract and, as far as is ermitted, they bring the wires into positions where the magetic lines are as short as possible.

Slowly moving electrons are more effective in ionizing toms than are the swift ones. The effectiveness of the lectronic grasp, which requires time for its establishment, ather than the vigor of an electronic impact, is what acomplishes the dislodgment of an electron from an atom.

Electrostatic positive and magnetic charges in material odies represent deficiencies and excesses of electrons at heir respective surfaces. These charges may start radiating urrents in the surrounding medium, if this is not completely onconducting; but since the charge, with good insulation, ersists, it cannot itself partake of the nature of a flow f electrons, but implies an electronic posture, *which is exlicable if the electron has unlike poles.* Electric current, owever, is an actual flow of electrons from the negative o the positive pole of a battery, or the reverse of what was ormerly supposed. The electronic twist is indicated by the esulting field of magnetic force attending the current. If he body of an observer is supposed to coincide with the irection of a current, the stream of electrons entering at is head and passing out at his feet, a north-seeking magetic pole, as seen by him, will always be deflected by the urrent toward his left. This rule is invariable and shows hat it is not a matter of indifference which way the elecrons rotate. The direction of rotation is always the same, or is always clockwise when one looks away from the source in the direction along which the electrons are flowing. In Figure 2 the inflowing poles of the electrons are marked *i*, and the outflowing *o*, while the direction of rotation is indicated by the transverse arrows.

The posing of successive tiers of concentric revolving shells, arranged in pairs with alternation of revolution, gives the needed provision for several tiers of chambers (called for, but not explicitly explained in Langmuir's scheme *), and they are ready to be inhabited by symmetrically placed supernumerary electrons, all moving at great speed in local orbits but with their centers of motion fixed in respect to certain significant directions on which chemical and crystallographic properties depend. This fixation of centers of motion makes for stability and the directional control of atomic positions in stereochemical complexes, thus reconciling the obvious coexistence of extremely rapid internal motions and a static structure with fixed nodal positions in the atom. Positive and negative electricities are explained as the obverse and reverse of a single vortex. All electrodynamic forces result from the interaction of magnetic fields, either similar or opposite; because in the last analysis, potential energy is nothing else than distortion of some kind of vortex-structure in the universal aura which is the birthplace and storehouse of energy, such as, for example, the contraction of a line of vortex-spin in the case cited, is a conversion of potential into kinetic energy.

Unless vibrating or revolving in some way and held by internal magnetic forces, Langmuir's internal electrons, if they stood still, would seek the atomic surface by mutual repulsion and would there form a static electric charge. But nothing in these smallest entities ever stands still. Parson's model, which lacks any sufficient magnetic inner control, and is constructed with artificial restraints which would not be found in a real atom, exhibits magnetons which tend to set with their planes radially disposed, giving a closed magnetic field. Langmuir's theory that valent electrons are held in common by the juxtaposed atoms of a molecule, requires that whatever magnetic revolutions are involved, the axes of electronic revolution shall assume a mean position, thus that they shall commonly be parallel to the axes of both atoms. When the volumes of the uniting atoms are notably different, the valent electrons of the larger atom must be displaced and considerably drawn together to fit the pattern of the smaller atom. The union will be easier, other things being equal, for atoms of similar sizes. Conformably to this principle, when hydrogen, or finely divided aluminum, or magnesium are burnt in oxygen, the union of these elements whose atoms have very similar volumes, takes place either explosively or with exceedingly intense illumination.

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* "The Arrangement of Electrons in Atoms and Molecules," Journal of American Chemical Society, Vol. XLI, June, 1919

Langmuir (*op. cit.*, page 886) considers that "in all of the elements between gold and niton the positions of the electrons are determined mainly by electrostatic forces," but admits that in some cases magnetic forces enter into the electronic arrangement. For example, he attributes the sudden increase of diamagnetic properties at bismuth to the lack of symmetry due to the odd number (five) of valent electrons. "The extra electron displaces the others and thus weakens the magnetic forces and strengthens the electrostatic." The "holding" forces between the electrons in the atom are said to be "predominantly magnetic" (*op. cit.*, page 884), and to be attracted magnetically the electrons must obviously have orbital motions. Yet even so, it is difficult to conceive a complex scaffolding of octets without something more substantial to fasten them to. My plan supplies this lack and, if the electronic revolutions be admitted, gives a reason why the centers of motion should be preferably in latitude 45°, thus favoring the cubical disposition.

Since the significant intercalated electron of the magneton is revolving more rapidly than the adjacent mass-giving electrons, its orbital plane may vibrate a little, but can not depart widely from a middle position between two consecutive shells. Parson's model does not show these relations satisfactorily, because it omits the representation of the shells and, instead of centers of motion distributed by repellant forces between the electrons, the model substitutes centers of solenoidal electric currents which are rigidly fixed by construction.

Without entering upon the complexities of the heavier atoms which require elaborate chemical and spectroscopic studies for their unraveling, I will just touch upon a few points connected with the structure of the two simplest atoms. In my view the two supernumerary electrons of helium are internal negative electrons needed to complete the exact equality between the numbers of positive and negative electrons; and this is why (since the resulting magnetic fields of positive and negative electric current are also equal) helium is strongly diamagnetic, while the absence of external supernumerary orbits makes it also without valency. If, however, the atom of helium can be forced into an atom of oxygen, helium's pair of extra electrons unite with the six valent electrons of oxygen at its maximum valency to form the stable but nonvalent octet of neon (atomic weight $= 4 + 16 = 20$; Moseley number $= 10$). The fact of this transformation has been discovered by Ramsay. The completion of the Langmuir octet gives us neon, a substance without affinity, satisfied, saturated,—because, viewing our subject from the spiritual side, it has in it with correspondential power, the cube of 2, or good to the utmost, as does every other satisfied substance. If the octet is not formed, there is not satisfaction, and there must be the "desire" for change.

Hydrogen, which has but a single supernumerary electron, is also diamagnetic and therefore has equal numbers of positive and negative electrons with equal and opposite currents. It would also be without valency, were it not that it may lose its single external supernumerary electron, becoming thereby converted into a positive ion ($H+$) which unites with a neutral hydrogen atom encircled by its single electronic orbit, the supernumerary electron serving to unite the two by its magnetic attraction for a positive ion, so that this gives a combination in which the atoms act as if monovalent. The neutral hydrogen atom behaves as if it were negative towards the positive ion, although the neutral atom is devoid of any cubically placed valent electrons of the ordinary sort. Since, however, the single supernumerary electron of hydrogen is equivalent to a valent electron and can so act, even though not placed in the ordinary diagonal position, this atom may be denoted by the symbol H —.* But it appears that there is also a genuinely negative hydrogen atom which has yet another supernumerary electron. We may presume that in this case the two supernumeraries revolve in parallel but external circles about either pole of the atom, or else they oscillate in an equatorial plane, differing from helium merely in the superficial position of the two electrons which thereby become valent. It should be capable of capturing *two* positive hydrogen ions, forming in this way the molecule H_3 which in fact is known to exist.

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* Langmuir (Science for November 5, 1920) finds that this arrangement is electrically possible; but so is the union of two nuclei by a pair of electrons, oscillating as in the central pair of helium.

Sir William Ramsay seems to have had a somewhat similar idea in regard to the valent electron of sodium, though this is not placed in the same position as that of the hydrogen atom. He says: "Union between an atom of sodium and one of chlorine consists, in all probability, in the use of the electron of the sodium. The formula Na — Cl^{VII} would appear to represent the compound, because as soon as that salt is dissolved in water the electron is undoubtedly associated with the chlorine atom; we have Na surrounded by water molecules, on the one hand, and on the other, — Cl^{VII}. Aq."

In his lecture on "Compounds of Electrons" at the inauguration of the Rice Institute,* Sir William Ramsay said: "As yet we cannot account for the fact that two electrons, moving in opposed parallel paths, attract each other; it is merely another instance of the inexplicable problem of 'action at a distance', which has puzzled all philosophers since the time of Newton and earlier, and even now we are no nearer an explanation." I venture to hope that congruity of magnetic spin and the resulting blending of similar harmonious curvilinear motions among the primal particles of the universal medium will be found to be an explanation of electrodynamic attraction. In a general way, the conception may not be wholly new. Sir Oliver Lodge's "Modern Views of Electricity" is full of attempts to make rotating models work according to electrical prescriptions; but I have not anywhere found precisely the above application of the principle to the atom, considered as an electrical mechanism, nor one which harmonizes so many diverse points of view.

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* The Rice Institute Pamphlet, Vol. 1, No. 4, page 423, July, 1915.

Lewis, while formulating the same idea that Parson has
t forth as to a cubical arrangement of valent structure,
akes valency wholly an affair of *electrical* attraction and
lls for stationary electrons arranged symmetrically at the
rners of a cube around an atomic nucleus which is elec-
cally positive. Langmuir stands for successive tiers of
ght electrons or derivations of the same and favors simul-
neous electrostatic and magnetic forces.

Parson* assumes a "magneton" with a radius of current-
rcuit $= 1.5 \times 10^{-9}$ cm., or about 10,000 times the radius
an electron, which Millikan has found to be 1.9×10^{-13}
n. Parson calls this current-circuit a "ring" and says,
resumably the ring is exceedingly thin" (page 3). One
ould at first suppose that he regards the magneton as a
in annular *disk,* but this would not agree with the ac-
pted definition of an electric circuit which gives an ele-
ent of magnetic field by a single turn. The conception,
stated, is vague. He says: "The unit negative charge
distributed continuously around a ring which rotates on
axis (with a peripheral velocity of the order of that of
ht)," as if he contemplated stretching the unit charge to
dimensions of this extended orbit. But currently ac-
pted electrical theory does not admit any such variation
the form of an electron which is regarded as a perfectly
finite least particle of electricity, though according to
theory of the electron, the superficial velocity is indeed
at of light. The only alternative is to let the electron
cupy at any given moment a single point on the orbit,
ter the manner of Swedenborg's active substantials, in
ich case the charge is not "distributed continuously" as

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* A. L. Parson, "A Magnetic Theory of the Structure of the
om." Smithsonian Miscellaneous Collections, Vol. 65, No. 11,
pages, 1915.

averred. Inquiry might be made whether successive pr sentation of the single electron at different points along tl orbit will not give all the continuity needed for magnet purposes, although this does not remove the difficulty regard to radiation and resulting instability. The auth apparently tries to cover up this weakness by obscurit Bohr simply ignores it.

The plan described in my paper on "The Luminifero Ether" calls for an electron which is a definite particle i capable of distortion and having a velocity at all points its surface which is exactly equal to that of light (and he Swedenborg's elementary particle fulfils the requirement if designed for it); but the electronic vortex approaches t spherical form and could not readily be stretched into ring of wide aperture and still retain this equable surfa velocity.

The difficulty urged by Parson against a ring compos of only a few electrons, that "these would radiate ener very fast" (page 6), does not apply to the nucleus of r atom where many electrons are arranged in a given ring w juxtaposition of opposite electronic poles (or congruo rotations, another feature which Swedenborg has predicat of his "elementaries") which produces a completely rege erative system during steady motion. Barkla's suppositi that the atom contains but few electrons is transferred my atom to certain supernumerary electrons of great s nificance in electric luminescence and to those which co stitute the Moseley number. Their relation to the electron shells prevents the dissipation of energy during stea rotation.

A second objection is made by Parson to Thomson's ato namely, "that for diamagnetic atoms it is necessary assume the existence of independent orbits in om that are so great in number or else undergo such pid variations that they can be considered to have their es uniformly distributed in three dimensions—this to count for a zero resultant magnetic moment. Now sepate rings of this sort can not maintain their individualities less the difference in their radii is so great that their sturbance of one another is inappreciable. This condition, granted, would limit the possible number of rings and the ance of their resultant moment being zero altogether too uch, for most substances are diamagnetic; while if the dii are not different enough to prevent interference, an ogether chaotic motion will result in the atom. Hence tating rings of electrons, where they can exist at all, must coaxial, and all atoms containing them must have a magtic axis" (pages 6-7). This dilemma, which would equally fect any particle formed on Swedenborg's plan, is wholly moved by my explanation that positive and negative elecons differ only in pose. In my atom the electronic orbits *e* coaxial, and yet the atom need not have a magnetic axis, cause in order to produce a diamagnetic atom it is only cessary that the magnetic effect of the positive electronic bits shall be equal and opposite to that of the negative es; and in general this is the case, so that paramagnetism exceptional. Thus the objection urged is wholly in favor my atom composed of coaxial revolving shells of positive d negative electrons on a sort of modified "bullular" pothesis.

The special advantage of Parson's theory is that it gives explanation of the para- and diamagnetic relations of the ments and their compounds in a great many cases, acunting for some very puzzling peculiarities,—such as the ct that so extraordinarily magnetic a substance as iron n give a diamagnetic salt. Any theory which will explain

such a case as this, deserves the most hearty welcome.
appears probable, however, that Langmuir's theory wi
account for these peculiarities equally well or better. Th
axes of rotation of the magnetons may be so arranged "th
the magnetic field of the atoms is nearly wholly interna
in other words, so that the magnetic moment is zero. Suc
atoms are diamagnetic" (Langmuir, *op. cit.*, page 883

Again, both Parson's and Langmuir's theories emphasi
the importance of groups of eight electrons arranged aroun
the atom at the corners of a cube; and for the reality
this arrangement we have the testimony of A. W. Hu
who found by the X-ray analysis of the crystal structure
iron that "if all the [26] electrons [indicated by the Mosel
number] are displaced from the center of the atom alo
the cube diagonals in four groups of 2, 8, 8, 8, at distanc
1/32, 1/16, 1/8 and 1/4 respectively, of the distance to t
nearest atom, all the observed facts are accounted for with
the limit of experimental error." * This result was obtain
for crystals of iron in a "silicon steel containing about
per cent. Si and practically no carbon." At first sight
apparently settles the question of the distribution of a s
of *fixed* electrons within the iron atom. These electro
agree in number with the Moseley number for iron, b
since this number has been explained by a theory whi
assumes *revolving* electrons and the applicability of Keple
laws to such revolutions, since also the magnetic properti
of iron suggest that here at least there are electrons whi
are revolving and are magnetons, one is led to query wheth

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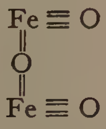
* Physical Review, 2d Ser., Vol. 9, page 86, 1917. The obser
tions rest upon the scattering of the X-rays by electrons app
taining to the atoms in their relation to crystal planes who
indices were 110 (observed in 1st, 2d, and 3d order spectra
100 (orders 1 and 2), 211 (orders 1 and 2), 310, 111, 321, 4
210, 332, 431, 510 and 521.

these electrons which scatter the X-rays need be fixed, and whether they do not act magnetically upon the X-rays while revolving in small orbits, provided the orbital centers be fixed in respect to the rays. Hull's arrangement of electrons in the iron crystal is called for in Langmuir's theory of the iron atom (Langmuir, *op. cit.*, pages 878-9). The same arrangement is attributed to cobalt and nickel except that these have one and two extra electrons respectively, which are assigned to polar positions. Of these three elements Dr. Langmuir says: "The present theory thus explains in a perfectly satisfactory way the anomalous position of iron, cobalt and nickel in the periodic table. We shall see that it also accounts for their unusual magnetic properties."

This, however, does not end the complexity according to Parson, since he adds a magnetic number to the Moseley number, or at least he assumes an addition of six "magnetons" to make four groups of eight in the iron atom, instead of three groups of eight with an innermost pair; so that the "Parson number" for iron is 32. Obviously the six can not affect the X-rays and can not have the same function as the twenty-six, but must differ structurally. On the supposition that the six are valent magnetons, the chemical constitution of ferric oxide is that given in the annexed diagram, according to the older mode of representation of chemical "bonds." Hull's experiment favors, if it does not confirm, the Langmuir theory. By the theory of "co-valency" which Langmuir has proposed, there should be six electronic covalent pairs of electrons in ferric oxide,



$$\begin{array}{l} \mathrm{Fe}\equiv\mathrm{O} \\ \| \\ \mathrm{O} \\ \| \\ \mathrm{Fe}\equiv\mathrm{O} \end{array}$$

$O - Fe = O = Fe - O$, which is shown diagrammatically in the figure where heavy lines unite covalent pairs.

Derivation according to Langmuir's rules:
Valent electrons; iron, $e_{Fe} = 8$; oxygen $e_{o} = 6$. Number of atoms; $n = 5$. $\Sigma e = (3 \times 6) + (2 \times 8) = 34$. Covalent pairs; $p = (8 \times 5) - 34 = 6$.

Parson's argument for the addition of six electrons to all the elements between helium and iron rests on the supposition that there are six as yet unisolated elements between hydrogen and helium. But in my view all of these new elements have an equatorial ring of electrons whose valency is no greater than that of hydrogen. Nicholson finds that it is necessary to divide Planck's constant by five for protofluorine. Evidently the five electrons in its ring act as one, or each has one-fifth the ordinary value of a single revolving electron.

In order to explain the fact that there can not be more than eight valent electrons, Professor Lewis,* like Parson, adopts the conception that they may be arranged at the corners of a cube, though he does not make them revolve. The hypothesis immediately raises the question: Why should the outer electrons be arranged at the corners of a cube? Why not six at the corners of an octahedron, or twelve at the centers of the faces of a dodecahedron? What is the significance of the number eight? We had a reason for this in Thomson's atom, because of the instability of a Mayer pattern of over eight magnets in a ring, and in my scheme because of the 45° position of the valent orbits which are kept there by mutual electrostatic repulsion, controlled by the electronic shells. Lewis answers the question: Why not some other number than eight? by saying that the

* Gilbert N. Lewis, "The Atom and the Molecule." Journal of American Chemical Society, Vol. 38, pages 762-785, 1916.

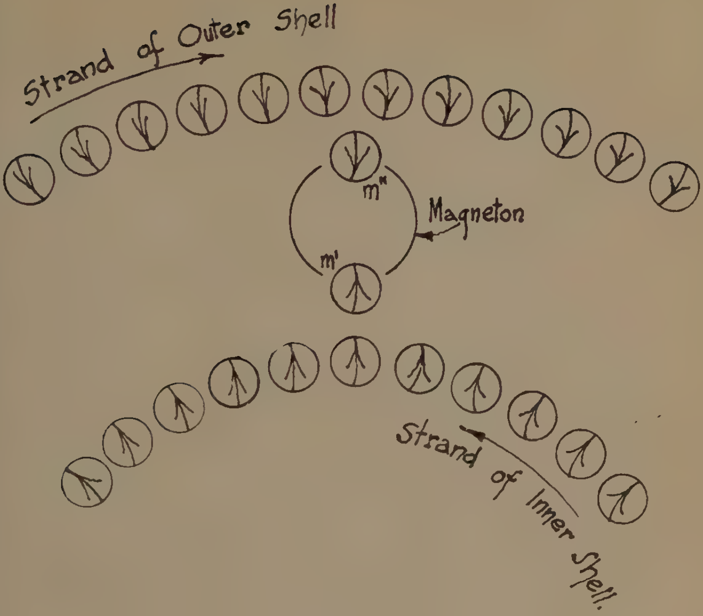


FIGURE 2.

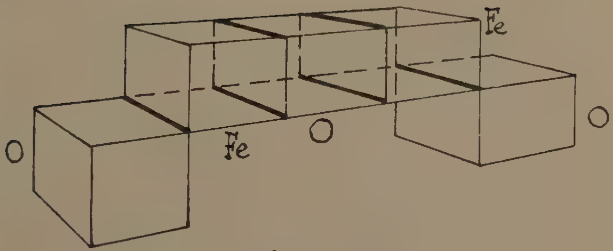


FIGURE 3

termost shell *may* indeed hold either 2, 4, or 6 electrons,
stead of 8, though never more than 8. Langmuir, how-
er, holds that for stability it is necessary that the outer-
ost shell of an atom shall contain 8 electrons, though some
these may be held in common by adjoining atoms, and
is constitutes chemical union of atoms in molecules.

Be this as it may, the X-ray test confirms the existence
the cubical system of apparently fixed electrons (which
ay also be magnetons) in crystals of iron. Even if the
lent electrons be diverse from these inner ones, to keep
om being electrically expelled, at least the inner electrons
ust be circulating. Parson's hypothesis makes chemical
inity a magnetic attraction. A hydrogen atom may be
amagnetic, with exactly equal numbers of revolving po-
ive and negative electrons; but ionize it by subtracting
e valent revolving electron and the ion becomes endowed
th magnetic properties from the remaining uncompensated
volutions and seeks its mate. Simple thermal movements
ay often be sufficient to account for chance contacts and
sult in chemical union of ions; but the explosive velocity
th which hydrogen and oxygen ions combine calls for a
ore powerful and well directed attraction of magnetic
rtners.

Having adopted the hypothesis that chemical affinity is
e to electrical, rather than to magnetic attraction, Lewis
kes objection to Bohr's supposition that the electrons in
e atom move in fixed orbits and that they continue in this
tion even at a temperature of absolute zero. He says:
ow this is not only inconsistent with the accepted theory
electromagnetics, but, I may add, is logically objection-
le, for that state of motion which produces no physical
ect whatsoever may better be called a state of rest" (*op.*
., page 773). But the first of these objections is removed

by my hypothesis that the electrons are bipolar with reent
ing and outflowing poles (after the manner of one of Swe
enborg's vortex-particles), receiving and emitting the au
in their progressions; and that they are conjoined by juxt
posed poles of opposite polarity during their orbital circ
lations (again following Swedenborg's prescription), formi
stable strands of uniform spin (save possibly in valent a
supernumerary electrons where stability is secured by t
attraction of balanced pairs). The excess magnetic fi
of the mass-giving electrons, arranged in paired shells,
competent to command a variety of dispositions of t
supernumeraries. From the interclasping magnetic fields
the general revolution of the mass-giving electrons wit
the atom, a powerful magnetic inertia is produced, whi
is independent of chemical or thermal changes. Lev
ignores the inertia of the atom which is nevertheless *a ve
notable but constant "physical effect."* The rotations a
revolutions of these same mass-giving electrons *contin
unabated at the absolute zero of temperature*, and they
immune to all outside interference. The second objecti
is not valid because the atomic local motion, which cons
tutes the basis of thermal energy, has nothing in comm
with the unceasing movement of the electrons.

The argument for internal motion—both the general
tation of the atomic nucleus and also the local revolutions
diffracting and of valent supernumeraries with orbital ra
not over one-tenth that of the atom (probably much less)
is too strong to be lightly rejected. The extraordin
speed of the electronic and helium ejections from the rad
active atoms is proof of the intensity of these internal
tions, and it completely confirms Swedenborg's stateme
concerning the immensely greater power of interior act
motion when the least component particles are reached.

We have seen that Swedenborg concluded that matter is mposed of particles formed by motion and consisting of her smaller particles also in motion, but with far greater pidity, and these of still smaller particles whose motions e at a still greater and inconceivable speed. More than century elapsed before facts were discovered confirmatory a small part of the general supposition, and then nearly nother century elapsed before the full power of his ar- ument began to dawn upon the scientific mind with the sult that, even now, there is much hanging back and nwillingness to accept the obvious implications of the data ade known by the radioactive transformations.

We may also believe that the electrons are the long-sought ortex-particles predicted by Swedenborg, and that the yrostatic reversal of the spin of these particles is the origin f Planck's "wirkungs quantum," or least quantity of en- rgy, with a value of $h = 6.55 \times 10^{-27}$ erg seconds, which also the starting point of the "light-quanta" which give ndividual spectral rays. We may also note that Sweden- org thought that light was a modification "singillatim" A. E., n. 726), that is, in least details—an expression for hich we may now substitute "light-quanta"!

Swedenborg's proposition was that the elementary par- cles are all exactly alike. We may now say the same of e electrons. Endless diversity is possible from the ar- ngement of these in the atom, giving by their perturbations e infinitely varied details of line-spectra, but the funda- ental unit is everywhere one and the same invariable entity.

In the early days of chemistry, Prout formed the hy- othesis that the atom of hydrogen is such a least entity and at the other atoms are simply built up out of groups of ese. Historically, that is, from the viewpoint of a gradual volution of the elements through successive annexation of lesser atoms to form the greater and more complex, the id is probably partly true; but there may be more than o component atom. The electric "atom" fulfills every ne in respect to minor discrepancies, because its mass increas at great speeds, and it is one of the outputs from the d composing radioactive atoms. Prout's hypothesis had be abandoned when Joseph John Thomson discovered th there are corpuscles having less than a thousandth of t mass of a hydrogen atom, that they are "atoms" of ele tricity, that the mass of an atom may be wholly electric and in short that the electron is (as Fessenden, Rams and others have maintained) the universal element—whi I have here identified with Swedenborg's "first elementa particle" of the vortical sort. Some temporary doubt a confusion have arisen from the prevalent idea that the ato consists of only a few electrons, instead of many thousan which it must possess on the foregoing principles, but th doubt I have removed by showing that since the electr is a cored vortex (again according with one of Swedenborg conceptions, though for a definite reason and not simply a speculation), since it has unlike poles, and since the tw electricities arise simply from the presentation of one the other pole of the electron, it follows that great numbe of electrons can be consociated in completely paired *a* *electrically neutral* counterparts which are not in eviden chemically nor in line spectra, whereas the few supernume ary electrons on which electric and chemical properties d pend have hitherto monopolized the attention of physici and chemists. The paired shells take the place of Swede borg's "finites."

Swedenborg has much to say of circular motion with his particles. Today, almost the whole of spectrosco science is concerned with the frequencies of vibration ıerions arising from revolutions of electrons moving with- the atoms in circular orbits. The relative positions and nensions of these electronic orbits form one of the great tstanding problems of spectroscopic research, but their istence is certain. They conform to Kepler's laws of bital revolution, but the famous astronomical "problem of ree bodies" is completely eclipsed by the complexities of e electronic maze. A brief review of the historical steps which this spectroscopic evidence has been established ll have to suffice, but on every hand points of contact ll be found with Swedenborg's great new departure which signed structure and motion to the interiors of matter.

About the middle of the nineteenth century, Stokes, Bun- n, and Kirchoff independently established the fact that the emical elements, when heated in flames, give out special mogeneous light-waves which are characteristic of the ven substances. Immediately, a new era opened in as- onomy with the formation of the branch of astrophysics. the study of their spectra, sun, stars, nebulæ, comets, eteors and terrestrial substances could be analyzed and eir composition could be ascertained notwithstanding the moteness of some of these objects. The properties and lations of terrestrial substances could be studied in a ıolly new way. New chemical elements and new proper- s of matter were soon discovered in this way, and the ıole field of the invisible minute motions within the atoms, reseen by Swedenborg, was opened up to investigation. ith the discovery of the Roentgen rays, another and al- ost equally potent means of entering into the minute struc- re of matter was made possible, while the phenomena of dioactivity and the disintegration of the atoms opened a w world to view, with vistas of the conquest of new urces of energy dimly seen as possible in the remote future, and even the realization of the old dream of th alchemists—the transformation of the chemical elements

Langley, in 1878,* found that the "Great A" and "Grea B" bands in the solar spectrum (now known to be produce by the absorption of oxygen in the earth's atmosphere) wer made up of a few series of similar pairs of lines symmetrically disposed; and Higgs of Liverpool showed that in an given series the frequencies of vibration corresponding t these lines could be represented by the equation of a parabola, each line falling exactly on the curve.

Of the ordinary appearance of the lines in the spectrum o the sun, Langley wrote: "There is no more apparent orde in their arrangement than in that of undergrowth in a primitive forest, or of any other disposition of natural object which we assign to chance. But, if in walking through suc a forest, we came to an open space in which the trees wer planted two and two, with the most formal regularity, w should hardly doubt that something else than chance ha been at work. . . . If we further found that the space between the pairs were themselves not casual, but arrange with exactness in a certain progression,—if we found a this, we should certainly, in the ordinary use of language say that here Nature had given place to art. If, further or we saw a second arrangement like the first, which resemble it closer the more we examined, we should find our conclusion for design, if possible, strengthened. . . . Wha might be called the result of intelligence, if observed i another field of Nature, we must here call conclusive evidence of the existence of law" (*Proceedings of the American Academy of Arts and Sciences*, Vol. XIV, page 93)

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* "On Certain Remarkable Groups in the Lower Spectrum. Proceedings American Academy of Arts and Sciences, Vol. XIV page 92, 1879.

The writer at this time had just gone to Allegheny to come Professor Langley's assistant. One of his first duties s to make micrometric measures of the positions of these es, and he well remembers the awe and amazement with ich he saw these marvelous harmonically related pairs nding out conspicuously in the midst of a crowd of other ar lines which had no obvious order whatever (albeit we nnot doubt that if the intricacy were disentangled, other s obvious series and harmonies would emerge to view). e harmony thus emphasized in the given instance sug- sted the orderly arrangement of the planets in their orbits. By all the evidence of his senses and by all the intuitive gings of his reason, the man of science, brought face to ce with these marvels, is compelled to utter the word esign." But the deeper we plunge into the mysteries of e universe, the more amazing is the evidence of intelligent sign *everywhere*. To call this phenomenon "law," and t to omit all mention and reverent acknowledgment of e Divine Lawgiver, is not an evidence of "intelligence" the man of science. Let him mend his ways! Let him me up higher into the mount of vision and acknowledge at *order* is of the Divine Provision!

At about this time, or just a little before, Huggins (also e of the fathers of the then nascent science of astro- ysics) had found in his study of the spectra of stars of e type of Sirius and Vega that those spectra exhibit very ong lines due to hydrogen and forming a harmonic series th its limit in the ultra violet, at a wave-length which is w known to be $\lambda = 0.^{\mu}364702$. Subsequently, two more ries of harmonically related lines, making three in all,* re discovered in the spectrum of the hydrogen atom, besides a more complex spectrum of very many faint line without any evidence of series among its lines, which ha been assigned to the hydrogen molecule, but possibly is du to the individual electrons in the concentric spherical shell

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* Recently still a fourth series has been found farther out in e infra-red spectrum.

Stated in terms of Rydberg's universal formula for line series in spectra, the three well-known hydrogen series are

(1) Ritz series: Frequencies $= \nu = N \Big(\frac{1}{(1)^2} - \frac{1}{m^2}$
wave-lengths of lines $= 0.^{\mu}121567$, $0.^{\mu}102572$, 0. 097254
wave-lengths of lines $= 0.^{\mu}121567$, 0. 102572, $0.^{\mu}097254$
etc., limit $= 0.^{\mu}091175$.

(2) Balmer series: Frequencies $= \nu = N \Big(\frac{1}{(2)^2} - \frac{1}{m^2}$
wave-lengths of lines: $H\alpha = 0.^{\mu}656463$, $H_{\beta} = 0.^{\mu}486269$
$H\gamma = 0.^{\mu}434169$, etc.; limit $= 0.^{\mu}364702$.

(3) Paschen series: Frequencies $= \nu = N \Big(\frac{1}{(3)^2} - \frac{1}{m^2}$
wave-lengths of lines $= 1.^{\mu}875609$, $1.^{\mu}282154$, 1. 094105
wave-lengths of lines $= 1.^{\mu}875609$, 1. 282154, $1.^{\mu}094105$
etc.; limit $= 0.^{\mu}820579$.

These wave-lengths are computed in microns (thou sandths of a millimeter) for a vacuum with Rydberg's con stant, given by Birge as N = 109, 678.705,* *m* being an integral number greater than the number in parentheses i the denominator of the first fraction of the formula. Theo retically, *m* may have any value up to infinity which give the limit of the series; but actually the number of line which can be observed depends upon the temperature. Th hottest stars give about thirty members of the Balmer serie for hydrogen. The first series is invisible, being wholly i the ultra-violet part of the spectrum and, indeed, in tha

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* This number gives the number of waves per centimeter, an its reciprocal must be multiplied by 10,000 (the number o microns in 1 cm.) to give the corresponding wave-length i microns, or by 2.999 x 10^{10} to give the number of vibrations pe second.

xtreme ultra-violet part, known as the Schumann region
hich is absorbed by air and can only be photographed in
vacuum. The second series extends through the visible
pectrum and into the ultra-violet. The third series is in
e invisible infra-red region.

These details will serve as an illustration of the beautiful
rder and harmony which reigns within the atom. The
d Hα line corresponds to 456,842000,000000. ethereal vi-
rations per second; the violet Hγ line to 690,746000,000000.
brations. This may be compared with the vibrations
f sound in air, where middle C is usually taken at
omewhere between 250 and 265 vibrations per second.*
wedenborg's surmise that the ether particle's vibrations
re immensely more rapid than those of air is fully con-
rmed, as is also his view that the interiors of matter are
tructured by motion in successive discrete orders.

How far superior, how much more reasonable and satis-
actory is this view to that of Newton! In Newton's
Opticks" we read: "It seems probable to me, that God
n the Beginning form'd Matter in solid, massy, hard, im-
enetrable, moveable Particles, of such Sizes and Figures,
nd with such other Properties, and in such Proportion to
pace, as most conducted to the End for which he form'd
hem; and that their primitive Particles being Solids, are
ncomparably harder than any porous Bodies compounded
f them; even so very hard, as never to wear or break in
ieces: No ordinary Power being able to divide what God
imself made one in the first Creation" (pages 375-376).

Nor were Newton's conceptions of his light-corpuscles
ny more refined. He questions: "Are not gross Bodies
nd Light convertible into one another, and may not Bodies

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* Musicians have seldom been scientists and their choice of a
tandard has been a matter of taste.

receive much of their activity from the Particles of Lig which enter their Composition?" (page 349). "Are n the Rays of Light very small Bodies emitted from shinin substances?" In these queries, light is not differentiat from matter in any respect, except possibly by being ma up of "hard" particles a little smaller than the averag Compared with the most enlightened opinion of his tim Swedenborg is seen to be some centuries ahead of his age

It is recognized that the above phenomena of the spectru are founded on intra-atomic motions and structures. T reason why there are *four* harmonic series in the spectru of the simplest of atoms is supposed to rest on whether t displaced electron returns to the 1st, 2d, 3d or 4th stab orbit. Rydberg's equation is partially explained by D Bohr's theory according to which the single free hydrog electron is in rapid revolution around the center of the ato In the collisions between the atoms, which result from the thermal motion, the electronic orbit is more or less disturbe If the disturbance is sufficiently violent, the electron ma be ejected from its original orbit and may pass to a ne orbit; and the process may be repeated. But only certa orbits are stable, namely, those for which m varies by su cessive additions of unity. The steps by which the displac electron returns to equilibrium are recorded by the seri lines. Individual atoms are continually acquiring and losi energy through collisions and the temperature of a g expresses the statistical average vibratory energy of t gaseous particles as far as their motion is capable of alter tion by outside attack. The utmost thermal change, ho ver, is relatively minute even in an incandescent gas, com-ared with the energy of the general revolution of the mass-ving electrons within the atom, which is unchangeable.

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* While in London as a young man, Swedenborg writes to brother-in-law, Eric Benzelius, librarian of Upsala Universit "I study Newton daily." He came therefore directly under t influence of Newton's teaching but was not overawed by authority.

We speak of "inner energy" of atoms and molecules in ermodynamic theory, and we distinguish between this tent inner energy of rotation or vibration, and the energy f translation of the particles which is sensible heat; but ese thermal motions are all of them superimposed on those otions within the atom which are constitutional and only aried in slight adjustments of a few valent electrons in emical reactions. Small as these chemical adjustments ay be, they are often made known to us by what seem us terrific explosions, although the disturbance of inmost ergy is but a minute fraction of that which would be vailable did we but know how to release its bonds.

We must conclude that this extraordinary immunity of e inmost atomic energy from change is a sign of a different atus in the least constituent particles which are "self oved" as Swedenborg tells us, so that they are exempt rom interference of outside agencies.

The fundamental vibrations in the X-ray spectra where e frequencies of corresponding lines, such as the first, or α line of the K series, increase for the heavier atoms, but approximate proportion to the square of the number of upernumerary electrons, and not according to the atomic eights, show that this atomic property is controlled by lectrical, and not by gravitational forces.

Many metallic spectra have series of pairs of lines, or f triplets, in the visible spectrum. Here the law is more omplex and chemical properties are involved. If $\Delta\nu$ is the ifference of frequency of the lines of a pair, and $\Delta\nu_1$, $\Delta\nu_2$, f the lines of a triplet, the same values of the constants holds for all the members of a given Mendeléeff peric of the chemical elements in the formula

$$\sqrt{\Delta\nu} = m\,(N - N_0),$$

where N is the Moseley number of supernumerary electron N_0 is a number which represents the inductive effect of tl other electrons upon the radiant one, and *m* is a consta (Stewart). The same formula applies to the elements other periods, but with different constants. Here the a rangement of the outer, or valent, electrons appears to ha control, and as these are the electrons which determine tl chemical properties, the two effects are alligned. But tl fundamental frequencies of the X-rays progress with gre uniformity and are not correlated with chemical period Moreover, they are so exceedingly rapid that presumab they must come from central electrons which revolve und the influence of a central force in orbits of very sho radius. These are all similarly situated, forming an inne most structure in all of the elements from helium upwar and they are not involved in any variations in the chemic properties. Hence the greater simplicity of the law whi governs their numerical relations.

We might suppose that the radiant electrons are eith oscillating about a mean position in the atom, or that th are revolving about a center. The phenomenon of tl Zeeman effect, or the splitting of a spectral line into tv or more paired components under the action of a stro magnetic field upon the heated vapor of the element, i dicates that here, at any rate, the motion which is at tl bottom of the action is an electronic revolution which d termines the frequency, though it is probable that an osc lation is superposed upon this primary motion. In any ca these numerical relations are a striking confirmation Swedenborg's doctrine that it is motion, and motion of cular sort, which forms these entities and which discrim- ates between their several states. Moreover, he appears have been successful in assigning to the primordial ele- entary particles out of which matter is formed, the precise nd of complex revolutionary motion required to maintain eir electric and magnetic properties.

In addition to this, Swedenborg's theory consistently calls r structures in three dimensions, and here he stands with e chemists, though as regards orbital motion he is in some spects in line with the physicists also.

Radiation is an affair of surfaces, but the heat from which originates affects entire volumes. As Swedenborg puts it, at affects the particles "by volume" (*volumatim*). The ght-producing mechanism which is concerned in electric minescence may, indeed, have a two-dimensional structure, it it exists as a minor component in a more extensive three- mensional form. By dwelling solely on the radiant and ectrical properties of the atoms, the physicists are neglect- g thermal and gravitational requirements which must fulfilled by a complete theory. The necessity for looking these things tridimensionally is paramount.

In ascribing to Swedenborg's theory such a complete view, am not forgetting that in the opening passages of his ac- ount of the creation of atmospheric forms, he speaks of imal motions as if they were circular, or at most plane irals. But it seems to me that here he is using a symbolic mathematical logic and is concerned with a first com- onent of motion. He is also speaking the language of hilosophy and has not yet descended to concrete termin- ogy. The primal particles must be, as Osborne Reynolds aintained, virtually perfect spheres. If their superficial ergy has to return to the center, it must be by excessively arrow polar cones of practically infinite angular velocity, both poles being similar or indrawing poles, and with production of pressure at the center, which perpetually resuscitates the internal motion.

The inherent tendency to reproduce their own interna motion outside of themselves, which is predicated of the primordial finites, ceases after a triple compounding in the third finites, or electrons. All the activities previous to this form have been as much under the divine guidance as is the growth of the fœtus in the womb. The newly born element now brought forth and launched upon its independent career, is less potent from creative energy and is no longer capable of reproducing the inner motion unaided Henceforth the particles which succeed in their order follow Newton's laws of motion. The cathode rays progress in a rectilinear path, unless deflected by some extraneous force. The electronic orbital revolutions within the atoms are as much under the guidance of a central force as are the movements of the planets which, but for the sun's attractive force, would be rectilinear. The electron therefore, marks the boundary between motion which is inherently curvilinear and "self existent," and that motion with which we are familiar from observation.

In his great work on "Electricity and Magnetism" (Art. 822), Clerk Maxwell says: "The consideration of the action of magnetism on polarized light leads, as we have seen, to the conclusion that in a medium under the action of magnetic force, something belonging to the same mathematical class as an angular velocity, whose axis is in the direction of the magnetic force, forms a part of the phenomenon. This angular velocity cannot be that of any portion of the medium of sensible dimensions rotating as a whole. We must therefore conceive the rotation to be that of very

nall portions of the medium, each rotating on its own axis.
his is the hypothesis of molecular vortices."

The term "molecular" in this extract should not be in-
rpreted in the strict sense of the chemist, for chemical
olecules are apt to be complicated affairs and do not rotate
s a whole in the emission of light, any more than do con-
derable portions of a universal medium; but the rotating
r oscillating units of the luminous and magnetic phenomena
re discrete particles of a much finer order than molecules.
ven when the wave-length of a vibration is some kilo-
eters, as in the pulsations used in wireless telegraphy, in-
tead of microns as in ordinary radiation, the particles con-
eying the radiant energy are of the order of magnitude
f the electrons (radius about 2×10^{-13} cm.).

The important point is that the medium by which mag-
etic transitions are affected must be composed of discrete
inute particles capable of rotation, that is, the medium
onsists of discrete vortices; and the same is true of the
aterial structures from which luminous impulses originate.
nd the two can interact.

The evidence points to a three-fold order of vortices, each
ne formed successively by aggregation of numerous in-
ividuals of the preceding order arranged on a vortical plan,
ut not necessarily nor probably on precisely the same plan.
hese three orders are: 1, the atoms of gravid matter;
, the electrons, or "atoms" of electricity; and 3, what I
ave called the "aurions" of the universal aura.

All of these elementary vortices are alike in several re-
pects: (1) They all have definite spatial dimensions which
ary, if at all, within rather narrow limits. The atoms have
iameters a little over 10^{-8} cm. The electrons are a little
ver 10^{-13} cm. in diameter; and perhaps we may be permit-
ed to guess that the aurions are not far from 10^{-18} cm. in

diameter, the three having a somewhat uniform progression as to size.

(2) While all of these entities have both internal and external fields of energy, the mode changes suddenly at a limiting surface, although this surface is not to be thought of as a geometrically continuous boundary. For example: The atom of hydrogen consists of 1844 electrons arranged on a pair of juxtaposed spherical layers, the outer constituting the boundary of the atomic nucleus according to the plan described in my paper on "The Luminiferous Ether" (page 24). With the above named dimensions, this means that each electron on the outer shell occupies only about one ten-millionth of the area of the atomic sphere. This is much closer than the spacing of the planets in their orbits around the sun; but still the arrangements of great and small have a certain family resemblance, in that the unoccupied spaces are much greater than those filled by the definitely limited units. It also accounts for the fact that a certain amount of atomic interpenetration is possible. Between the several electrons, keeping them apart and yet permitting them to act on one another across these wide intervals, are the aurions out of which the electrons are formed by some special arrangement and motion of the parts. In this atmosphere of the universe there must be a much closer juxtaposition of parts even to a fairly close contact, so that there can not be much compression anywhere in the medium. We recognize that this must be so because the aura is enormously resistant to certain forces, yet it is almost infinitely elastic, with hardly any viscosity, and thus, though nearly incompressible, it is extremely mobile. The aura appears to be the ultimate reservoir of energy in nature, completely filling tridimensional space and therefore constituting a virtual plenum.

Now these vortical particles of the aura must be the immediate receptacles of the Divine Creative Energy which forms and sustains the material universe and which is derived from the Spiritual Sun. This primal Energy being uncreate is unalterable; and so likewise its physical counterpart (the "energy" of the physicist) can not be destroyed, but can only be rearranged in its spatial distribution. To this extent we seem forced to admit the existence of primal particles such as Swedenborg conceived. To the aura and its wonderful wave-motions of light and gravitation, together with its wider magnetic vortical movements which link together the very great and the very small—the galaxies and the atoms—we must ascribe the fundamental office in the play of physical forces.

Each of the three orders of particles consists of entities which are so many working machines; and since every machine must consist of at least two members, giving the possibility of action and reaction, there must be this distinction into two parts in each of these tiny particles. There must be in each an active interior and a restraining boundary on which the activity reacts. Thus the electron appears to be a vortical whirl in the aura whose rotary speed (and the resulting centrifugal pressure) forces back the surrounding aura to a limit at which the velocity becomes so great that were it to become any greater the medium would break, which would of course destroy continuity and prevent any further transmission of the activity. Hence the electron is a vortex-ring, a cored oblate spheroid, nearly spherical, intensely active within, but enclosed by a superficies of condensed and highly resistant aura which limits or finites the entity. The outer boundary is aura condensed to the limit. The inner contents are also aura, but rarefied by intense rotary motion which presses outward against the barrier.

Hence, in a way, the structure may be compared to a bubble, except that in the latter the outer liquid pellicle retains a sphere of compressed gas, denser than the surrounding medium, which is the opposite arrangement to the electronic one. It will be seen that analogies must not be pushed too far; and Swedenborg's "bullular" concept would be quite misleading if we were to imagine a series of repetitions of the *same* identical structure. With the proviso that the details of structure vary, the general proposition, that elementary particles resemble bubbles, has much to be said in its favor. The electron is a sort of bubble and so is the atom. It is permissible to surmise that the aurion is no exception to the rule, and Swedenborg's ascription to it of perpetual influx from a spiritual source, back of which is the Divine Creative Power, is a rational solution of the problem of the basis of all natural forces.

CHAPTER V.

SWEDENBORG'S DOCTRINE OF A SIMILARITY BETWEEN GREATEST THINGS AND LEAST IN NATURE

BEFORE going farther, we must draw up an enumeration of the general conclusions which may now be reached in respect to the structure of an atom—here selected as a representative of one of the least things in nature, but regarded as a world in miniature with a history, an independent motion of its own, an inner structure, a vibratory state, perhaps an external magnetic field and other properties which permit us to regard the atom as a type.

We have seen that the passage from the older astronomy which deals with the gravitational interaction of great masses, to the newer astrophysics, hinges precisely on this approach of scientific research to the ultra-minute, that is, on this transference of thought from greatest things to least,—or we might say, in an emblematic way, from a Newtonian to a Swedenborgian point of view. The latter is necessarily the more complete, because generals are made up of particulars and the generals can not be understood until the details are comprehended.

The atom, according to the description outlined in the preceding pages, answers to the following requirements founded on observation:

(1) The mass of an atom must be wholly electrical and arises chiefly from the combined gravitational effect of the thousands of pulsating electrons in its superfices and concentric inner layers. The mass of the characteristic electrons, which are concerned in chemical reactions, is insignificant.

(2) The inertia of an atom results in part from the angular momentum of these mass-giving electrons in rapid

revolution around a polar axis which is the axis of an atomic vortex,—and in part from the axial rotation of each individual electron which gives to the electron itself inertia. Any shifting of a mass of matter in space involves a dragging of these complex vortices through the adjacent aura and a redistribution of energy.

(3) Atoms are more or less magnetic, if their opposing solenoidal currents of electrons are not wholly compensated. Even when there is compensation, there are still internal closed magnetic fields within each atom. Apparently, compensation is the rule, because most substances are diamagnetic.

(4) The *thermal* properties of the atoms and their atomic volumes which are connected together by a fixed law, are governed entirely by the number, motion, arrangement, condensation and dimensions of the concentric electronic spheres. Each addition of a new pair of matched electronic shells accounts for a wave in Lothar Meyer's curve of atomic heats.

(5) The continuous spectrum of solids, liquids, and strongly condensed gases, arises solely from perturbations in the complex electronic orbits of the atomic superficial layers induced by collisions, that is, thermally. If a single electron in the spherical surface is disturbed from its position of equilibrium, all the others follow. An impetus which approaches one of the poles of the atom as a superficial wave, gives progressively shorter waves by crowding the successive electronic orbits of the shell more closely together; but in receding from the pole the orbits are expanded and the waves are lengthened. Thus waves of a continuously varying length are produced from each atom in a long series, forming a continuous spectrum when analyzed by the spectroscope. A sufficiently vigorous impulse

may produce a surface oscillation of wide range and the motion may pass meridionally between poles many times in succession before being damped out of existence. From this process there also results the movement of the position of maximum energy in a spectral energy-curve towards the shorter wave-lengths as the temperature increases,—a movement which was discovered at Allegheny Observatory and described by Langley in 1886 in the *Annales de Chimie et de Physique* (ser. 6, tome 9) and for which a law was found by Wien.

(6) The addition of a new pair of electronic spherical shells to an atom in the process of its evolution, not only increases the atomic volume *per saltum* and advances the atom by one step in the Mendeléeff atomic series, but it gives largely increased facility for receiving superficial vibrations. It is a noteworthy fact, and one which lends strong confirmation to the theory given under (5), that the atoms at these nodal points of the periodic series are the ones which are prone to exhibit more or less continuous spectrum in conjunction with their bright-line spectra, even when they are vibrating as highly rarefied gases in flames of a Bunsen burner.

On the other hand, considering the bright-line spectra *per se*, we find a list of properties which are eminently *electrical* and which appertain to the relatively free and characteristic electrons, and not to those which are grouped in the spherical shells. The characteristic electrons form so small a part of the whole that, gravitationally, they are as if nonexistent, and thermally, they are of little account; but electrically, they are supreme, as the remaining numbers in this list of properties of the atom will show. Very distinctive is:—

(7) The *sharpness of the lines* in the bright-line spectra

of the elements. This sharpness testifies to the suddenness and discreteness of the perturbations which originate the lines. These vibrations are peculiar to the characteristic electrons (except in the resonance spectra already cited) and arise either through their explosive transition from one stable orbit to a new one, or else, secondarily, by a momentary inductive disturbance which the initial motion exerts on the other associated supernumeraries. If the characteristic electrons are inside the atom (as seems to be certain from the X-ray analysis) we should expect them to be less easily influenced by thermal vicissitudes arising from impacts, and to be more readily acted upon by electric perturbations. Thus we have been led to associate bright-line spectra with *electric luminescence* which may or may not be accompanied by heat, but to which heat is not absolutely indispensable, as it is for the production of a continuous spectrum.

(8) Heat pushes the atoms apart in a molecule and pushes the molecules apart in a freely expanding gas, but does not enlarge the atoms themselves to more than a very small extent.

(9) Gravitation is powerless to effect the union of atoms into molecules, but this union is altogether accomplished by electric and magnetic interaction of those characteristic electrons which give to the atoms their valency and special capacity for chemical union.

(10) Gravitation is equally powerless to produce the rapid revolutions of the electrons within the atoms, but these are due to forces which are wholly electrical. The velocity of the single characteristic electron of a hydrogen atom, assuming that its period is that of the most rapid frequency of the hydrogen spectrum (namely, 3.29×10^{15} vibrations per second) will reach 1.1×10^{8} cm./sec. if the radius of the orbit is one third of the atomic radius. Its

centrifugal force will then reach 0.07 dyne and will be just equal to the attractive force, and if the electron is outside the atom and moving in the same period, its speed will be nearly that of light; but evidently, since the central attractive force in this case is less than the centrifugal force and was only barely able to overcome it at one-third of the radius of the atom, it follows that an outer electron will not be retained unless revolving more slowly than the assumption.

(11) The velocities of the characteristic electrons in their orbits have been computed by Nicholson for nebalium and protofluorine, where the accurate coincidence of the predicted frequencies with observation justifies the hypothesis that a few characteristic electrons are grouped in a ring. The velocities amount to a few thousandths of the velocity of light; but much greater velocities should be found in the heavier atoms because the central force is greater. If the characteristic electrons of the inmost ring of the uranium atom have a velocity one-third of that of light, the radius of the electronic orbit is 5.72×10^{-11} cm., since the fundamental convergence frequency for the K-rays is $\nu = 2.785 \times 10^{19}$ vibrations per second by Moseley's law which says that this frequency is proportional to the square of the atomic number, which is 92 for uranium, and this gives $\nu_u = (92)^2 \times \nu_H = 8644 \times 3.29 \times 10^{15} = 2.785 \times 10^{19}$ We are led to believe that some such velocities as one-third of the velocity of light do actually occur within the very heavy atoms—uranium, thorium, and radium—and that this is why they are unstable, namely, because an increase of velocity to that of light would mean immediate destruction to the atom, and even a near approach to that limit may be dangerous.

(12) The complete bright-line spectrum of an element includes at least three orders of vibrations—the hard, me-

dium, and soft rays (K, L, M) of the X-ray tube, and more for the heavier atoms. The last alone extend to the region of visibility for the heavier atoms. The three corresponding series for hydrogen have already been given. The alkalies have three harmonic and intimately related series of lines, known as principal, first subordinate, and second subordinate series, and each series has characteristic peculiarities. The heavier atoms which possess larger numbers of supernumerary electrons, exhibit a complexity in their bright-line spectra which almost defies analysis. The meaning of these relations is still very enigmatical, but there can be no doubt that the hidden harmonies result from the variations and perturbations of internal revolutions of electrons.

I will give an example of the computation under (10) to show how Kepler's laws of orbital motion apply to these minute intra-atomic revolutions, but with the difference, as compared with the planetary orbits, that in the atoms, forces immensely stronger than those of gravity are needed.

COMPARISON OF GRAVITATIONAL AND ELECTROSTATIC FORCES IN THE HYDROGEN ATOM

From the gravitational data of the Earth-Moon system, we can calculate the period of revolution (t_2) of an electron about the atomic nucleus of the hydrogen atom, if gravitationally produced, as follows:

Mass of Earth	$M_1 = 6.1 \times 10^{27}$ grams
Mass of Moon	$m_1 = 1/80 \times M_1$
Mass of Earth + Moon	$M_1 + m_1 = 6.18 \times 10^{27}$ grams
Mean distance of Moon	$r_1 = 3.844 \times 10^{10}$ cm.
Sidereal month	$t_1 = 2360592^{\text{sec.}}$ (2.361×10^6)
Mass of atom	$M_2 + m_2 = 1.662 \times 10^{-24}$ gram
Radius of atom (assumed = that of orbit)	$r = 5.5 \times 10^{-9}$ cm.

Formula:

$$t_2 = \sqrt{\frac{r_2^3 \ t_1^2 \ (M_1 + m_1)}{r_1^3 \ (M_2 + m_2)}} = 7{,}793.^{\text{sec.}} = 2^{\text{h.}}\ 9^{\text{m.}}\ 53^{\text{s.}}.$$

With Millikan's value of the charge on an electron:

$$e = 4.774 \times 10^{-10} \text{ e. s. units}$$

two electrons 1 cm. apart ($r = 1$) and of positive and negative sign, which are of the same respective charges as nucleus and satellite, attract each other electrically with a force of $e^2/r^2 = 2.279 \times 10^{-19}$ dyne; and at distance r_2, or atomic radius,

ELECTRIC FORCE $= f_{2e} = 2.279 \times 10^{-19}/(5.5 \times 10^{-9})^2 = 0.0075$ dyne. The gravitational attraction of two masses, each of 1 gram, and 1 cm. apart, is 6.66×10^{-8} dyne, and this reduced to the condition for the atomic problem gives

GRAVITATIONAL FORCE $= f_{2(g)} = 3.30 \times 10^{-42}$ dyne.

$$\text{Ratio } f_{2(e)} : f_{2(g)} = 2 \times 10^{39} : 1.$$

To accomplish N revolutions of the electron of mass m, and charge e about the nucleus of charge E, with h = Planck's energy constant, Bohr's theory gives

$$\text{N} = \frac{2\pi^2 \ \text{e}^2 \ \text{E}^2 \ \text{m}}{\text{h}^3} = 3.29 \times 10^{15} \text{ rev./sec.}$$

i. e., actually $t_2 = 1/(3.29 \times 10^{15})$ sec. This leaves the orbital radius undetermined.

I will add one other example relating to the gravitational problem. Take the Kα vibration of a hydrogen atom and assume that its period is also the period of the pulsation of an electron. The pulsation may be very much more rapid than this, but can hardly be any slower than the electronic revolution. The gravitational force between two electrons in an atom, assuming that they are pulsators and according to Hicks' theory of successive alternate "images" of the motion in a single pair of spheres, is

$$F_1 = F_2 = -\frac{4\pi^3}{T^2} \cdot \frac{a^2\ b^2\ \alpha\ \beta}{r^2} \cos\theta,$$

where $a = b =$ here the radius of an electron, say 10^{-13} cm.,
$\alpha = \beta =$ amplitude of pulsation, say 10^{-20} cm.,
$r =$ distance between centers $= 5.5 \times 10^{-9}$ cm.,
$1/T^2 = 1.082 \times 10^{31}$, since T, the period of pulsation $= \frac{1}{3/4\ \mathrm{N}} = \frac{1}{3/4 \times 3.29 \times 10^{15}}$, by assumption,
$\theta =$ phase difference of pulsation for two electrons. If $\theta = 0°$, this gives the pulsating force on an electron $=$ $\mathrm{F} = 4.438 \times 10^{-43}$ dyne, equivalent to 4.524×10^{-46} dyne, equivalent to 4.524×10^{-46} of the weight of a gram.

The computation is made on the supposition that the amplitude of the electron's pulsation is $\frac{1}{10{,}000{,}000}$ of the radius of the electron, which is a little too small by the result of the preceding computation, or else the density of the enclosing atmosphere must be slightly greater than is assumed in the formula. (See W. M. Hicks, "On the Problem of Two Pulsating Spheres in a Fluid." *Proceedings Cambridge Philosophical Society.* Vol. III, page 282, 1879.)

Hicks says: "If the theory offered is the true one for the explanation of gravitation, it would be possible to have celestial systems, the parts of which in each would obey the law of gravitation, but which would not influence each other, or would repel each other." Evidence has now been adduced in my paper, "On a Possible Limit to Gravitation," which strongly confirms this conception. The relative crowding of the galaxies is so great that it argues a mutual repulsion between these larger parts in a system of another order.

The numerical illustrations which have been given will at least serve to indicate approximately the order of magnitude of the phenomena of the atom. If the atomic structure is that which is here specified, several legitimate inferences may be made:

Metalloids, among which monatomic molecules do not occur, have perfect symmetry in the distribution of electrons in their electronic shells which require the addition or subtraction of an electron to make these atoms asymmetrical, before there is any tendency to union; for perfectly symmetrical things have no individual character and lack that analog of sex which leads to the attraction of chemical affinity. But the metals have spheres of electrons arranged presumably with a slight lack of symmetry, so that positive and negative electricities predominate respectively on opposite hemispheres. Atoms of this sort are always electric doublets and can form monatomic molecules; whereas atoms in which the distribution of the two electricities is entirely symmetrical have to be ionized by gaining or losing electrons, before they can combine to form a molecule in which one or more atoms, or groups of atoms, having opposite electric signs, play the part of the dual members of an electric doublet. The forces producing chemical union, cohesion, and rigidity, are either of electric, or magnetic (revolving electric) origin and exist between axially directed pairs in a doublet. The gravitational attraction, even between juxtaposed atoms, is, as we have seen, so minute as to be entirely negligible, and the masses of the atoms do not enter into the formula for molecular attraction at all; but the directions of the axes of the doublets must be considered, and the force, unlike that of gravitation, is proportional, not to the inverse *square,* but to the inverse *fourth power* of the distance (as is the case for associations of magnets) and has therefore a very limited range. The mathematical expressions for the forces within and between the molecules are very complex; but those for the electronic motions within an atom follow gravitational models somewhat closely, the forces diminishing as the inverse square of the distance, and the movements being of the nature of long-enduring orbital revolutions, or short-lived vibrations of orbital planes; whereas the internal movements of the molecules are linear reciprocations of their atoms, or oscillations of their axes through small angles; and these either die away rapidly or, if of great energy, disrupt the molecule.

Members of the helium group are peculiar in that they are devoid of chemical affinity. They are the "hermaphrodites" among the elements.

Consider two layers of molecules in a solid in thermal equilibrium. They are linked together by the attraction of the alternating directed polarities of their constituent atoms. Both the molecules and their atoms are in continual vibration and collision. There result incessant electronic perturbations which generate innumerable *quanta* of radiation, and though these are continually reabsorbed, there remains a certain amount of interatomic radiant energy which is altogether energy of the ether and which must be distinguished from the thermal (kinetic) energy of local motion of the atoms and molecules.

The force of gravity is exceedingly minute compared with the electric forces within the atoms and gravity is incapable of condensing the aura; but electromagnetic forces of a suitable sort, associated with each individual electron, can generate etherions out of the aura, and these, while they remain attached to the electrons, are like atmospheric sheaths or coverings to these bodies; but these envelopes become free radiant etherions whenever a negative electron is transformed to a positive one by a gyrostatic uptilting (or *vice versa* a positive to a negative) flinging off its corresponding radiant quantum of energy by so doing. This apparently alternating sign of successive lines in the hydrogen spectrum has been noted, but has not been understood heretofore.

Heated bodies are continually losing etherions as radiant quanta, but each ether envelope is immediately restored by the electronic action on the adjacent aura, so that there is always an interatomic atmosphere of ether ready to take up any vibration which may be communicated to it by the electrons and ready to carry it away with the velocity of light as radiant energy.

Except when thus specifically energized, the ether remains condensed and attached to the atoms as atmospheres are to planets; and the ethereal condensation though, in general, greater around the denser atoms, is not held by their gravitational attraction but by the enormously greater electromagnetic forces. Being thus electrically controlled, the denser ether in transparent bodies gives to them refraction properties which are conditioned by optico-electric laws. According to Maxwell, the square root of the specific electric inductive capacity is equal to the index of refraction for certain rays of great wave-length. Through their associated ether, bodies which are opaque, as well as those which are transparent, are sometimes susceptible of magneto-optical effects. Such are the two Kerr effects—the rotation of the plane of polarization when polarized light is reflected from the pole of a magnet, and the double refraction produced when a transparent medium is electrically polarized, this polarization being an affair of molecular electric doublets which are analogous to magnets. (See Eugène Néculcéa, "La phénomène de Kerr et les phénomènes électro-optiques." Paris: C. Naud, 1902).

We have found ample evidence of the reality of Swedenborg's composite structured particles, formed out of smaller particles which also have structure and consist of least and most perfectly structured particles, in successive order,—the whole being conditioned by motion; and some of these particles approximate to a bubble-like form, as he supposed, though here certain modifications of the original specification are needed. But Swedenborg went further and asserted that there are gigantic "particles" formed on a similar plan and that the sun is a spherical shell of finites enclosing actives. He says: "The large active solar space could primitively have consisted only of the first finite. No space or place can be occupied or enclosed by actives, unless it is surrounded by finites in which alone it can be terminated and limited; and, consequently, in respect of which it can be called a space. By the tremendous action of this space the surrounding finites could be reduced into such an arrangement, that one might be in contact with another, and, consequently, enabled to finite themselves, and, by means of motion among one another, flow into second finites." (Swedenborg's "Summary of the Principia").

"Both the first and second elementary particles may now take their rise round this large active space; and may successively form a sphere which gradually grows larger, until at length they suffice to form a certain large vortex round the sun. For entities of both kinds are present, both actives and passives, of which the elementaries consist; since in the solar space are the actives, and round about are the finites, which consequently coalesce into particles and compounds partaking of both, and which, inheriting the force and character of both, receive into themselves both the active and passive principle. For this reason they are everywhere present in the world, everywhere they move and are put in motion; they occupy and are occupied; they act and are acted upon both as to their distinct particles and as to their entire volume; and, possessing as they do a perfectly compressible, mobile, and highly elastic surface, they can flow equally under the pressure of a large as of a small weight. In a word, it is thus that, in general, they may originate in the confines of the active space, where an abundance of each principle is to be found; just as in virtue of these two principles, vapors and drops arise on the surfaces of liquids; a volume consisting of actives occupying the internal space, and a volume of elementary parts pressing without. For elementaries can never constitute the surface of any particle, and be put in motion superficially, like the finites." (*Principia,* Part I, Chap. X, n. 5).

The last sentence coincides with a conclusion which we reached in Chapter IV that a change in the mode occurs when the electron is reached and free motion ceases to be inherently curvilinear and becomes rectilinear. We agree also that the sun is made up of actives of the first and second finites (inner thermal and electric energy) and of first and second elementaries (electrons and atoms). But that the latter form a shell enclosing an active space, so that, as Swedenborg puts it in his Summary: "Elementary nature is similar to herself both in the greatest and least things; in the macrocosm and in the microcosm; in a heaven and in a small volume; in a world and in a particle," does not seem probable except in a vague and general way. This is pushing the analogy too far. There is a certain superficial resemblance between the sun and an elementary particle, such that some recent writers have likened the sun to a bubble. The similitude consists in the limitation of a sphere of heated gas by a relatively thin outer layer of incandescent cloud—the photosphere. The sun has also an interior circulation of a vortical sort which makes it a magnet. Bigelow has shown that the curved filaments of the solar corona at minimum sun-spot epoch are controlled by the sun's magnetic field and the trumpet-shaped equatorial wings by an electric field. Hale has measured the strength of the magnetic field, both for the sun as a whole and in sunspots. Thus the sun has a certain rude analogy to an atom; but we have no reason to believe that there is any central active space differing in constitution from the rest of the sun. The density of the sun (about 1.4 times that of water) is such as might be anticipated from the known composition of that body, condensed by strong gravitational pressure, but under the expansion produced by intense heat.

It might be supposed from the passage last quoted, that the central actives and circumferential finites, which are said to "coalesce into particles and compounds partaking of both," were supposed to thenceforth fill the entire solar space, especially as it is said that the first and second elementaries "are *everywhere* present in the world," and this would accord with what we now believe to be true; but in Part III, Chap. IV, n. 2, we read: "Although all finites possess this power of self-activity, nevertheless, those which have their origin near the sun are not capable of becoming actives, of entering into the solar space to its actives, in consequence of a difference as to velocity, circles and mass; but the actives which may have been casually made, cease to be actives, and necessarily remain mere passives round the solar space of the actives"; and the fourth finites (atoms) are said to exist "near the sun," but not in it. This shows that Swedenborg imagined that the sun still retains its central active space into which first and second elementaries can not enter. Moreover, in Part III, Chapter X, n. 5, where aqueous vapor is described and where it is stinguished as separated from air by a dimensional degree vhereas we now know that there is no essential difference tween the two in this respect) we find that Swedenborg is not abandoned his early bullular hypothesis, although has modified it. He says:

> I would observe then that in every bubble of water there is ntained all that had previously existed from the first simple; ery kind of finites, actives, and elementaries, of which we ve treated in the course of our present work; so that in a nall bubble the whole of our visible and invisible world is ent. We have thus the macrocosm in the microcosm; the orld in a particle; the whole of our "Principia" in a nutshell. ture is the same in the greatest things as she is in the least; the whole as in the part. In the minutest things we behold e principles of nature's mightiest operations. For we see in bubble of water the fifth element or vapor, the aqueous surce, for instance, with enclosed ether; we have also air or the urth element of the world enclosed, as we learn from the eceding article; around the air we have the ether, or the third ement; around the ether, and in every particle of the air we ve the second element; around the second elementaries, as so in the air and the ether, we have the first element; thus have all the elements both without and within the structure d surface of the ether, and these all again enclosed within bubble of water.

A modern specification would read somewhat differently; r example: The liquid pellicle of the bubble consists of mplex water molecules (dihydrol and possibly trihydrol) intimate contact. The enclosure consists of molecules of ueous vapor and air, not in continuous contact, but in bratory motion with frequent collisions. These are composed of groups of atoms, enclosing electrons surrounded etherions, the whole interpenetrated by and formed out the aura.

Both sun and atom are spheres with intense internal activity. Except in this respect, however, there is little rea analogy between them. The radial convective circulatio of the sun is lacking in the atom. Where in the atom shal we find any counterpart of the crystalline purity of intensel white-hot photospheric clouds, curiously suggesting col rather than heat by their dazzling whiteness as of snow, an resembling snowflakes scattered on a fainter background Where for the filmy wreaths of the solar prominences, shin ing like burnished gold and copper on the opalescent back ground of the marvelous corona? Where for the intricat structure of the fiery maelstroms of the solar spots?

As flame the swift pulsating
Spears of the northern aurora,
Out of the ice-cold sky
That spheres round the realm of Polaris,
In rhythmical sheaves
Of weird unearthly splendor,
Arching the starry depths,
Cosmic, in ordered procession,
Marking as on a dial
Each life-throb of earth's benefactor,
Obedient to the impulsive,
Magnetical currents that flow
From the swirling eddies of fire
That surge where the solar tide
Rises and ebbs in majestic, slow motion,
In cyclical order recurrent;
So round the poles of the sun-sphere
Ever there sweeps and there surges
A vast, vague, rhythmical vortex—
Pillars of pearly pink fire-mist,
Curved like the wraiths of the magnet,
Branched like the antlers of stag's horns,
Curiously blended in mazy but ordered location.

  Nine times in a century
The great bright sun in his power
  Shakes his coronal locks
That are dipped in the fire-dew of ether,
  Nine times in a century
Responds earth's magnetic girdle.

Whence is the source of power to be found? Are we nearer to it in the solid rock, or in the lightning's flash? Whence come the awakening vitalities of spring's verdure and bird-songs? From the cold earth, or from the tenderly bending heavens? We reply that the source of power is always from on high, from the finer forces of nature which receive more directly the influx of spiritual life.

We have reason to believe that the variations in these wreathed and filmy forms of the solar corona are concomitant with internal changes in the sun which hold the key to the mysteries of terrestrial weather fluctuations. As I showed in my paper on "The Variation of Solar Radiation" (Astrophysical Journal, Vol. VII, pages 255-272, April, 1898), and in a paper, "Témoinage des Planètes concernant la Radiation Solaire" in *Bulletin Astronomique,* tome XXXIV, pages 129-135, Juin-Juillet, 1917, the intense convectional overturning which the sun experiences at a time of many and great sunspots, brings to its surface exceptionally hot material from the interior; there is a greater outpouring of radiation,* a much larger evaporation from the earth's tropical seas, exceptionally heavy rainfall, greater heat in the tropics, but exceptional cold in higher latitudes from the strong returning polar winds of our atmospheric convectional system. The planet Jupiter shines with a brighter luster. The snow caps of Mars melt away. On earth hurricanes are frequent. Auroras are seen in lower latitudes. Magnetic storms are witnessed. It is as when the Divine Love descends in the spirit, awakening to life, but precipating the Judgment on the evil, whereof Swedenborg was a witness.

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* This was denied and the reverse proposition was maintained in Abbot's revision of Young's work on "The Sun," but subsequently Dr. Abbot withdrew this statement and now coincides with the view which I have presented.

As the sun of this earth is said to be "dead," it can not receive any more immediate influx of energy from the spiritual world than that which inflows into the interiors of matter everywhere, whether in sun or earth. We have seen that Swedenborg teaches that energy is Divinely originated. Therefore it is indestructible. Science acknowledges the indestructibility in its fundamental doctrine of "the conservation of energy" and the interiors of the atoms are examples of its persistency. But just because this is so, it is not permissible to assume that a new sun begins from a new creation of energy, or by an addition of energy to the store already in the universe. The beginning of a group of suns is probably to be seen in the nuclei of condensation in a gaseous nebula. Some of the nuclei in the Great Nebula in Orion have already begun to assume the stellar condition, but with peculiar and relatively simple spectra (*i. e.*, these nuclei have a continuous spectrum, crossed by a few bright lines closely related to and in some cases coincident with those of the immediately adjacent parts of the nebula). The spectrum photographed by Dr. and Mrs. Huggins in 1888 is thus described by Miss Agnes M. Clerke in her "System of the Stars": "The light admitted on this occasion to the camera was obtained from the vivid central mass of the nebula, the slit in fact lying across two of the four bright stars grouped into the 'trapezium', which forms apparently the core of the entire formation. The pair of stellar spectra thus included in the photograph are seen . . . as two unbroken strips of light [extending far into the ultra-violet], crossed by the gaseous rays of the nebula. But not of the nebula alone. Three groups of thin and feeble lines belong, so far as it is possible to judge, primarily to the stars, though they are also emitted by the nebulous stuff in their immediate neighborhood. The stars then, since an indefinite extent of circumjacent vaporous material partakes of the nature of their glowing atmospheres, are *in* the nebula, and not merely projected upon it. They form an integral part of its structure."

The high temperature of a sun is not reached until a sufficient concentration of atoms has been attained. The mass of matter in a nascent sun is unusually large as compared with the stellar average and we may be sure that this matter is concerned in the development of heat, not, however, by way of combination, for there is no such thing within a sun. After many futile guesses as to the mode in which the solar heat originates, science in the last half of the Nineteenth Century had accepted the suggestion of Helmholtz, made at the Kant commemoration at Königsberg, February 7, 1854, that the heat comes from the using up of the potential energy of position of the expanded material as the sun contracts. The source of heat is a genuine one and is competent to give a thermal energy equivalent to the sun's radiant emission for some millions of years, but yet is inadequate to account for the long actual duration of a developing earth, dependent on the sun's rays for its heat. This led me to propose a different hypothesis which sees in the disintegration of the atoms of which the sun is composed a long-enduring and sufficient source of the thermal energy.

In *The New Christianity* for March 13, 1890, I said: "The lower degrees of material substance are successively limited. In ascending, they throw off their outer coverings and expand into fuller freedom and potency. A block of ice has but little power of motion. Transformed into water it has a greater activity. As steam it lifts great weights. Resolved into its chemical constituents, it becomes a dangerous explosive. Tear its atoms asunder, and gigantic solar maelstroms ensue at whose turmoil distant worlds may tremble. The grosser material substances change with the progress of time. Their underlying atoms seem more permanent; nevertheless, these also have a history, and have passed through an exceedingly prolonged series of changes, slowly moving onward to a final dissipation."

The idea was further elaborated and presented before the Astronomical and Astrophysical Society of America in December, 1901, and was published under the title, "A Cosmic Cycle," in the American Journal of Science.* The proposition that the atoms are breaking up and setting free their original energy of formation, and that this is the principal source of the sun's heat, was adversely criticized at the time, for it was then imagined that the atoms are eternal. But within a year, radium was discovered to be doing this very thing, and its atoms were found to be breaking up with evolution of a relatively enormous heat, although the decomposition is only partial.

The conception is completed by my further supposition that the atoms are reformed out of the energy which is continually vanishing into the entropy—the whole constituting a vast cycle of ascending and descending processes. The creation of the atoms begins in the emanation of light. The storing up of this energy is a process of enormous duration, but so is the gradual release of the energy to feed the fires f solar foci and to nourish the growing worlds. The upposition is further supported by the evidence of a pro-ressive "wasting of stellar substance" which is described n my paper by that title in Scientia for April, 1920.

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* (4) Vol. XIII, 1902, and in a French translation in Ciel et Terre, 23 Année.

Miss Agnes M. Clerke, in her "System of the Stars" (first dition, page 82) says: "Are the stars subject to growth nd decay? We might almost as well ask, are they subject o the laws of nature? There can be in either case no doubt bout the reply. We are perfectly assured, both from eason and revelation, that a time was when they were not, nd that at some future date they will have ceased to be. And we may further confidently affirm, guided by the nalogy of all other creative processes with which we are cquainted, that their present condition has been gradually ttained and will gradually become modified. Each has hen a life-history. It is what it is, because it has been what t was. Nor is it conceivable that all should have arrived simultaneously at the same stage of development."

Doubtless the atoms could tell a similar story. Some of them may have been much longer in developing than others. The incorruptibility of gold may be a result of the long and onerous vicissitudes which it has survived. Other substances have fallen by the way. This one has the virtue of the victor. The writer coincides with the opinion which Miss Clerke expressed and would merely add that the history of the stars is bound up with the history of the atoms. If one is not perpetual, neither is the other. They have their places in the panorama of eternal change.

If this is so, what shall be said of Swedenborg's assertion that the earth will endure forever? After what has been noted in regard to the disintegration of the atoms and the dwindling of the stars, the statement can not be literally true. I take it that Swedenborg was addressing the men of an age which firmly believed that the earth was created about 6,000 years ago and that it was shortly to be utterly consumed by fire. It was necessary to disabuse men's minds of this false belief and to assure them that the earth had already endured for enormous ages and would practically last "forever," as far as human conceptions go. Science has now assured us that the earth has already endured for some hundreds of millions of years and that it will probably last as much longer. In this sense science confirms the spirit of Swedenborg's "forever," though it may not be true to the letter.

"Sustentation is perpetual creation," says Swedenborg, and as regards the interiors of matter we assent; but a perpetual outpouring of solar energy without any replenishing from outside sources, is something more than sustentation. It is a distinct creation of new energy from moment to moment by immediate supernatural invasion of the solar substance, and not a sustaining of energy already in existence. It would be a violation of the natural mechanical law that, while energy may be transferred between different members of a system, its sum remains a constant. The perpetual emanation of radiant energy from the sun without replenishing the loss by imbibing fresh energy from some other portion of space would be a miracle, and the sun could not in this case be called a purely natural body composed of ordinary material substances, but would have powers not shared by terrestrial substances. We could no longer claim that the laws of nature are uniform, for there must, in this case, be certain portions of space—the regions circumscribed by stellar photospheric surfaces—where entirely different laws are acting, which have nothing in common with the laws of nature as exhibited in the outer spaces or upon terrestrial surfaces. The holding of such a position is disstrous to philosophy as well as to science. It takes us back o the Dark Ages when every doctrinal tinker felt free to ndow the universe with any sort of incongruous and fanciul device. Science has by great labor taught us that *one* aw prevails throughout the physical universe. The laws f matter or of force determined on this little earth, or ithin the limits of our solar system, are recognized by atural science as holding good upon the remotest star; and piritual thought reverently acknowledges that this fundaental unity of natural law is a sign and memorial that od is *One,* and that He will not confound us and dash ur intellectual inheritance into chaos. In this sense, namely, at nature is one and the same in greatest things and in ast, that the properties of electricity, or of iron, or sodium, re the same in the sun as on this earth,—Swedenborg's tatement is profoundly true, and is far more significant an taken literally in a fanciful comparison of suns with toms.

There are obvious resemblances between the creation of orlds and of organisms. Did suns blaze out instantaneously mid clash of elements, applauded by the pæans of celestial osts, as in Milton's poem, or is the power of the Infinite ather concealed in myriads of atomic vortices, hidden from e gaze of any other than the eye of reason, with the masty of the sun a thing of orderly slow development? Shall e say with Milton?—

> The Earth obeyed, and, straight
> Opening her fertile womb, teemed at a birth
> Innumerous living creatures, perfect forms,
> Limbed and full-grown. Out of the ground up rose
> As from his lair, the wild beast.

(Paradise Lost; Book 7, lines 453-457)

Did oak and palm, elephant and lion, appear on an unexpectant earth in a moment, or have organisms arisen from infusorial beginnings through ages of evolution?*

When the touch of antheridium or spermatozoön communicates the potency of organization to the germ of plant or animal, and we see a mysterious power lodged in a thing so minute as to escape the unaided senses—a power which dominates the entire life history and growth of an organism—does it not point to the origin of natural forms through these least things of nature by forces inflowing from a world without space, and by methods whose unity through the ages proves an ardor which time can not quench, or in other words, a spiritual potency not subject to time or space?

A wonder-loving age has demanded a sign. It must have theatrical pose. God must act the part of a magician. But we know that the Divine leading is gentle, and Divine Providence imperceptible. "After the earthquake" there came "a fire; but the Lord was not in the fire; and after the fire a still small voice" (I Kings, XIX, 12). Science bids us listen to the "still small voice" of *law.* Science overthrows the idols of supersitition; and those who love these idols may lament, because it seems as if the glory had departed from the ancient learning. But new ideas have arisen to take the place of the old, and the new are really much more wonderful than the old. Nothing has been lost by the giving up of childish notions. Enter reverently into the new temple of learning, where, indeed, as in the white shrines of Islam, you shall see no image of any earthly thing, but a light which can cleanse the mind of its imperfections and prepare it for a new revelation.

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* For a view which seems to me in accordance with the essence of Swedenborg's teachings, compare my paper on "The Theory of Evolution." New-Church Review, Vol. XXIV, pages 568-591, October, 1917.

The solar problem is a complex one. There is a structure to be explained for which there is no counterpart in the atom. There are peculiar laws of rotation, evidences of violent convectional motion, secular changes, varieties in chemical composition, extraordinary manifestations of physical forces; but nothing which is not similar in kind to terrestrial activities which were once attributed to special acts of deities. One of "Jove's thunderbolts" used to be kept as an object of veneration in a temple. We keep them now in museums and classify them according to chemical composition, or try to find out the comet or meteoric system of which they once formed a part. Shifting the burden of a prodigy on the shoulders of some god, when we have rational faculties which will lead us to the true explanation, is no longer regarded as legitimate, although it may be admitted that somewhere spirit and matter must meet. This meeting place we find in the least things of nature rather than in the greatest, and in the latter only through the former.

There have been some who have imagined that the Earth is a sort of bubble with a crust of sedimentary rocks and a molten interior; but determinations of the speed with which earthquake shocks are transmitted through the heart of the Earth show a rigidity which can be compared only to that of solid steel; and the recent very exact measurement of the tides in the solid Earth by Michelson and Gale, Astrophysical Journal, Vol. L, pages 330-345, Dec., 1919) prove that these tides are only 0.310 of what they would be if the Earth were fluid. Released from pressure, as at certain points where the strained strata buckle or break, the intensely heated rock may be locally softened to the melting point and extruded through some volcanic vent, especially if the melting point of the rock is unusually low, as in some water-bearing sediments, or if the minerals include an exceptional amount of radioactive heat-producing elements. Again the analogy between a planet and an atom is very vague.

A still more ambitious attempt at all-inclusiveness is reached when we come to Swedenborg's theory of the starry heavens; and here, wonderful to say, there does appear to be a real basis for the hypothesis; for Swedenborg insists that even as the elementary particles have their vortical axes simultaneously directed in consistent sequence into the larger form of a general magnetic vortex, just so the stars are grouped in a grand aggregate which possesses a spiral form:

> All the vortices which are directly in the axis of the sphere or sidereal heaven, are not inflected as to their axis; but their revolutions are spirally circular, and their center is in the middle; but round the axis, where they begin to be circumflected, their revolutions are elliptical, and their active center is in this case not in the middle; hence there are different and numerous eccentricities. Consequently our solar vortex is not in the axis of the sphere, but is near the axis where there is a considerable curvature or inflection" (Principia, Part III, Chap. I, n. 7). "The common axis of the sphere or starry heaven seems to be the Galaxy, where we perceive the greatest number of stars. Along the Galaxy all the vortices are in a rectilinear arrangement and series, and cohere as to their poles; in like manner, they are there more intimately associated, and have spires of greater curvature. The other solar or stellar vortices afterwards proceed from the axis, and are bent in different directions. . . . For here lies the chain and magnetic course of the whole of our sidereal heaven" (Principia, Part III, Chap. I, n. 8).

It is now generally admitted that the apparent circle of the Milky Way is the projection on the celestial sphere of the curves of a series of gigantic spiral arcs composed of millions of stars, the whole arranged on one consistent plan; and Sutherland has given arguments which indicate that the forces which control this vast aggregation are indeed magnetic. Nothing of this was known at the time when Swedenborg wrote, and the rest of his description, which it would be tedious to quote, is very obscure, but the general idea of a spiral circulation of stars under a magnetic control is astonishingly near the truth.

The globular star-clusters in several instances have been found to possess a total mass which is of the galactic order, but conjoined with an excessive condensation, which gives a far greater richness of stars for a given volume. Here the members of the group are pretty much under gravitational control; but in the spiral nebulæ the stars are too far apart for much of any gravitational interaction and they are borne along on streams of the aura under a magnetic control, as I have shown in Chapter VI, Section E. H. von Zeipel computes that the globular cluster, Messier 3, may have a density of stellar distribution 700,000 times greater than that in the neighborhood of our sun. Comparing the aggregation to an atom and the stars to electrons, there is a little resemblance, though the stellar internal motions are too small to be observed and the condensation is central in the cluster, but superficial in the atom.

In some other aspects there is not much resemblance between the astronomical and atomic systems, even though both come under the dominion of Kepler's laws. Rings of equi-spaced orbs are unknown in astronomy, whereas they are the rule in the atom; nor are gravitational forces strong enough to control such an arrangement and keep such rings in uniform revolution. The violent movement of electrons within the atoms would be fatal to the development of worlds and *therefore* such movements and forces do not find place in the entities with which astronomy deals; for who can doubt that these beneficent restrictions are provided for the sake of use? It is unthinkable that such things flow from blind chance and not from wise provision. The Master Mind can not be devoid of that prevision and planning which the humblest workman has to exercise.

Swedenborg's idea that the stars are governed in their motions by certain axial directions which are magnetically determined, is confirmed by Turner's observation that the system of stars of *Ursa Major* has a discoidal shape—the diameter sixteen times the thickness—and that it progresses *in the axial direction.* The motion *within* the system is too slow to have been determined as yet, but the discoidal shape of the group suggests that there may be a slow circulation of stars in the plane of the disk. The magnetic nature of the control of the axial motion (motion *along* the axis) follows from the general principle of the galactic motion which has now been ascertained.

Charlier and others have attributed discoidal arrangements of stars to interference and collision of members of the group under gravitational influence; but in my paper "On a Possible Limit to Gravitation" I have shown that the stellar motions of large scale are not gravitationally controlled, but are governed by the movements of currents in the magnetic aura. I have also shown in a paper on the nebulosity around *Nova Persci* * that this remarkable appendage was developed along lines of magnetic force. All of these things support Swedenborg.

These great movements in the interstellar atmosphere do not prevent every possible variety of small-scale motion. If the universal magnetic medium, or aura, flows through matter, or is not set in motion by material progressions, as is demonstrated by Zeeman in his paper, "The Hypothesis of the Immovable Ether," * the medium may nevertheless suffer a slight retardation in the vicinity of the matter which will have much the same effect as a permanent condensation. It is not necessary that the *general* motion of the aura shall coincide with that of the matter which is contained within it in any given small volume of space; for the matter, by its gravitational lines of force, takes hold of an immense volume of aura and is related to the general aural movement thereby, but yet is independent of any local aural motion in its immediate vicinity, except through the local magnetic field in case it may be amenable to magnetism. The aura as a whole may be moving in its own vast galactic sweep, but this grand movement is not immediately linked to that of the material contents of any small aural volume so that the two must coincide; that is, though exercising a large-scale control over matter, the aura is independent, or as if immobile, to the lesser motions of gross matter. Swedenborg also taught that particles of totally different orders of magnitude can not interfere.

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* "An Inquiry into the Cause of the Nebulosity around Nova Persei." American Journal of Science, (4) Vol. XVI, July, 1903.

Comparisons between great and small have been made by several recent authors, such as that by H. von Zeipel of Upsala, "Stars and Molecules." † Here the principal idea is that individual stars in globular clusters of great condensation may play the part of molecules in a gaseous mass, being held together by their mutual gravitation and kinetically related, if not by actual collisions, still at least by mutual interchange of momenta producing a general average of momenta through innumerable close approaches due to excessive crowding. Eddington finds only thirty stars surpassing 1/200 of the sun's mass in a sphere of 5 parsecs radius (5 × 206,265 astronomical units). The velocities of nineteen of these are known. For nine bright stars—absolute brightness between 48 × sun's brightness and 1/4 ditto—the average velocity is 37 km./sec. But ten faint stars—absolute brightness between 0.10 and 0.004 of the sun's—have the much swifter velocity of 86 km./sec. If it were possible, as von Zeipel supposes, to have so many collisions or near approaches among the stars as to give a kinetic average after the manner of the colliding molecules in a gas, then with $mV =$ constant, the smaller stars ought to have systematically greater velocities. But I attribute the observed phenomenon to an actual change of speed due to the loss of mass which the smaller (and therefore older) stars have experienced from destruction of their matter; and this view is favored by the spectra of the stars which show earlier stages of development for the brighter stars and later stages for the fainter and smaller ones.

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* Scientia, n. LVIII, pages 122-129, February, 1917.

† Scientia, n. LVII, pages 13 to 29, January, 1917.

But a more powerful argument has been given by Jeans against any analogy between stellar and molecular kinetics, for he finds that the "time of relaxation," or virtual freedom from interference, in gaseous molecules is only 10^{-10} sec., but that of the stars is 10^{14} years; and he concludes, it seems to me justly, that the kinetic theory is inapplicable to the stars. The entire duration of a star might be included in the interval between such infrequent approaches.

To sum up, we may say that there are certain broad analogies to be found in the groupings of approximately spherical bodies to form larger ones in successive order, provided one does not ask for minute duplication of detail. Arranged according to magnitude, we might name seven orders of spherical or nearly spherical bodies: aurions, electrons, etherions, atoms, earths, suns, globular star clusters. All of these can be arranged to form complex groups: For example, the aurions may be grouped in vortex filaments as magnetic lines of force. We can have also electric lines of force, electric currents or streams of electrons, Roentgen rays, rays of light, electric waves, sound waves, explosive waves, molecular groups, binary stars, nebulæ, etc., where analogies are overwhelmed in diversities, yet, since the larger units sum up the smaller, a certain amount of similarity is inevitable.

Let us enumerate the analogies between the atoms and the greatest bodies in nature, and also name the discrepancies:

1. The mass of an atom is the sum of the masses of its electrons, and its inertia is the sum of their angular momenta. Similarly, the mass of a galaxy or of a star cluster is the sum of the masses of its component stars; but the control of the motions in the one case is electrical and in the other gravitational, while the inertia of the large masses is to be referred directly to that of their individual electrons. There is here no precise repetition of a definite form of motion, but upon a larger scale.

2. The electrons rotate and revolve,—so do the several orbs with which astronomy deals; but the electron is self-moved from within, while the angular momentum of a planet is a resultant of whatever motions have been impressed upon it from without. A globular star cluster may be likened to a spherical atom with the stars for electrons, but the distribution of the stars is not like that of the electrons, and the electrons are revolving at tremendous speed, while the stars have so little relative motion that such motion has been detected with great difficulty and is not of the nature of a consistent simultaneous revolution of the whole.

Eight valent electrons are stationed at the corners of a cube within the atom. There are eight principal planets and at least one more trans-Neptunian planet, known to exist from the perturbations which it produces; but the planets are not placed at the corners of a cube and are not inside the sun.

As to the revolving electrons, their periods are governed by the same laws which Kepler discovered for the planets and with such accuracy that it has been found possible to predict Rydberg's fundamental frequency for hydrogen by these laws with a precision of one part in a thousand. Here there is analogy in the law, though the applications are diverse owing to the totally different arrangement of the parts.

3. Atoms are sometimes magnetic. The sun and the Earth are magnets. *Nova Persei* exhibited magnetic force on an enormous scale. The spiral nebulæ are controlled by magnetic forces. These are analogies; but, so far as is known at present, none of the heavenly bodies shows evidence of diamagnetism.

4. By far the greater part of the mass of an atom is concerned with its thermal properties, and the sun which supplies heat to our system also includes by far the greater part of its matter. In the evolution of suns there appears to be a single great curve of ascending and descending temperature. In the evolution of atoms there are six such thermal waves, attended by as many changes of volume.

5. The stars are so far apart that collisions between them can scarcely ever happen. In gases, on the contrary, collisions of atoms or of molecules are incessant, so that the interval between successive collisions in air at ordinary pressure and temperature is something like 10^{-10} second, while a like interval for the stars would be about 10^{14} years, according to a computation by Jeans.

6. There is nothing in the greatest entities which in the least resembles the electric structure of an atom, or the union of positive and negative electricities in permanent

association; and therefore, since the larger aggregations are not electrical, the atomic electric properties under headings 7 to 12 have no counterparts in the larger world.

Fournier D'Albe, in his book, "Two New Worlds," has attempted to formulate an elaborate succession of analogies between great and small, but on a too ambitious scale. He says: "Time and space are, after all, purely relative. If, at midnight, tonight, all things, including ourselves and our measuring instruments, were reduced in size 1,000 times, we should be left quite unaware of any such change." On this speculation Dr. Percival Lowell made the following searching comment: "The monstrosity of this statement, coming originally from the teachings of Kant but spelled now usually with a small *c*, instead of a capital *K*, fairly takes our scientific breath away. Not know it! Why the veriest child would perceive it at once, however unversed in physics. Every sensation dependent on two dimensions, the angular magnitude of an object for instance, would be altered in one ratio, while those dependent on three, weight for example, would be altered in another and even a baby on tumbling to the floor would wonder why he hurt himself less than yesterday—on that floor seemingly as far off as ever. . . . To persons untrained in, or averse to, mathematics such works do incalculable harm by leading them to believe that to be founded on figures which really founders on fact."

It seems to the writer that Swedenborg's somewhat similar thesis, though it does not commit the blunder just noted, is also open to criticism. There are undoubtedly several mportant analogies between great and small, but they should not be pressed too far, because the divergences and discrepancies are equally important.

Beautiful and wonderful are the intricacies of atomic spectra, but for outwardly visible grandeur and power we must give the palm to the solar cycles and to the majestic sweep of the galactic spirals which have no counterparts. Finally, the literal conception of a precise repetition of shape and structure is superseded by what Swedenborg says of the macrocosm and the microcosm, quoted in a previous chapter. The likeness between these is not in shape but in uses.

CHAPTER VI.

SWEDENBORG'S DOCTRINE OF HEAT AND LIGHT

SECTION A

IN order to give a reasonably complete treatment of the subject of this chapter, it will be necessary to include some things relating to matter and energy.

The forms of life in the vegetable and animal kingdoms, innumerable in their details, are conditioned in their habitats and modes of life within rather narrow thermal limits; and as climatic heat depends on the presence of the sun and its relation to the earth through radiation, we must postulate the sun's heat as a primary essential of life and not omit the light which plays an intermediary part in transmitting that heat to us. Nearly all the energy in the natural world is sun-derived. Heat and light, therefore, are instruments of creative energy, or contain energy, yet not in themselves, but as the instruments of more potent causes originating in the spiritual world, and in a Sun which precedes the sun of this world, and which the latter only images.

In his work entitled *Angelic Wisdom Concerning the Divine Love and the Divine Wisdom,* Swedenborg says:

> There are two suns through which all things have been created by the Lord, the Sun of the spiritual World and the Sun of the natural World. All things were created by the Lord through the Sun of the spiritual World, not through the Sun of the natural World. (n. 153). It is very necessary that it be known that there are two Suns, one Spiritual, the other natural; a Spiritual sun for those who are in the spiritual World, and a natural Sun for those who are in the natural World. Unless this is known, nothing can be properly understood about Creation or Man. (n. 107). That there is any other Sun than that of the natural world has hitherto been unknown. The reason is

that the Spiritual of man had so far passed over into his natural, that he did not know what the Spiritual is, and thus did not know that there could be a Spiritual world, the abode of Spirits and Angels, other than and different from the natural World. (n. 85).

In order that Swedenborg might found his doctrine on the things of experience, on which all genuine knowledge must rest, he was permitted to see the spiritual sun.

It appeared of the same size as the sun of the natural world; it also appeared fiery like it, but more golden. . . . The Whole angelic heaven is under that Sun. . . . Angels of the Third heaven see it constantly, Angels of the Second heaven very often, and Angels of the First or Outmost heaven sometimes. . . . All their Heat and all their Light as well as all things that are manifest in that World are from the Sun. (n. 85).

By that Sun which is before the eyes of the Angels and from which they have Heat and Light, is not meant the Lord himself, but the first proceeding from Him, which is the fulness of spiritual heat. The fulness of spiritual heat is spiritual fire, which is Divine Love and Divine Wisdom in their first correspondence. On this account that Sun appears fiery, and to the Angels is fiery, but not to men. Fire which is fire to men is not spiritual, but natural; and between the two fires there is a difference like the difference between what is alive and what is dead. Therefore the spiritual Sun by its heat vivifies spiritual beings and renews spiritual objects. The natural Sun does the same for natural beings and natural objects; yet not from itself, but by means of an influx of spiritual heat, to which it contributes power that serves as a kind of substitute. (n. 93).

In Dr. Holmes' magnificent hymn to the "Lord of all being" "whose light is truth, whose warmth is love," we have a scientist's acknowledgment that there is a purer heat and light than that of this world. Let us see if we can find in the treasures bequeathed to us by recent science, further confirmation of the doctrine that the natural sun is an instrument by which "a living force proceeding from the sun of the spiritual world" is able to actuate the forces of nature which we call *heat* and *light*.

There is an unquestionable affinity between Swedenborg's conceptions of these natural forces and those which are now held by science. In the eighteenth century, the great authority of Newton upheld the doctrine that light is merely a corpuscular emanation, and Swedenborg stood almost alone in maintaining that light while corpuscular is also an oscillatory motion in the ethereal substance, excited by vibrations of the least corpuscles within elementary particles. But today the vibratory theory of light is demonstrated; and likewise the corpuscular constitution of the *atom* (or "second elementary"), to whose "tremulations" Swedenborg attributed the origin of both luminous and electric phenomena; but besides this we have now the doctrine of the *light-quantum*, as a definite individual entity.* In his *Principia* he says: "If there be any corpuscles so small as to move only the ether, . . . and if these corpuscles circumgyrate, . . . they immediately put the ether in motion and cause light." The existence of these corpuscles (at first so named, but now called electrons) is today recognized through their isolation by J. J. Thomson.

Swedenborg continues as follows:

> The tremulation of this [dense] body causes in like manner a tremulation of the parts of the body, and of the minute corpuscles which inhere within it and are fluent without. In consequence of this tremulous motion of the body, the corpuscles in its interior particles being put into a tremulous motion, are impelled into gyres, . . . and together with these corpuscles both the ether inclosed in the body and that which is fluent without; for the ether thus put into motion communicates this motion to the circumfluent ether, this motion being assisted by

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* For confirmation of this position, I must refer to my paper on "The Luminiferous Ether," already cited.

that of the small corpuscles which float in the ether and continually issue from the dense body, and thus the ether becomes actuated into a whirling motion at a distance from its body, and hence also, as we have intimated, arises light, and in like manner a certain degree of electricity; for there are no bodies existing which are not in some way or other penetrated by the ether, in regard at least to their texture and their larger and looser composition (Principia, Part 3, Chapter 5, Article 21).

We recognize today that dielectrics may contain many electric corpuscles in the electrostatic state, and that they are usually particularly good transmitters of light. This passage does not describe the mechanism of luminous motion definitely enough to establish a claim for Swedenborg as the originator of an electromagnetic theory of light, but he was evidently looking in the right direction, and came very near to our present conception of electric corpuscles emanating from atoms, and by their local motion drawing after them vortex-tubes of the universal aura—contractile auralwhirls, the "Faraday lines of electric force"—as the following quotation shows:

The motion of the ether diffuses itself around to a distance in the form of a gyre. The motion enters into the texture likewise of the adjacent bodies, and causes these also to observe the same current and eddy of motion, and either draws them towards its own tremulous body or repels them from it. . . . In order for anything to be electric and to attract the lightest objects, a certain motion is required in the ether [that is to say, in the universal medium which Swedenborg sometimes calls a purer "ether," or magnetic aura.*] and one which is circumgyratory (loc. cit.).

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* Bearing in mind that these conceptions antedate by nearly two centuries their fuller confirmation by the progress of scientific discovery, we must pardon a little vagueness in the use of terms.

The transparency of certain substances is also referred by him to their permeability by the ether, which is interesting in connection with the modern discovery that, although not all dielectrics are transparent, there is no exception to the rule that all transparent bodies are dielectrics. In the same chapter (Article 20) we are told that "within one volume [of ether] in motion there may be similar and dissimilar motions, or motions concordant and disconcordant, or more or less harmonic; and all these may simultaneously pass through the organs of the eye, and simultaneously and similarly present themselves to the soul. Similar and harmonic motions may unite, and more powerfully move their mechanical organs; dissimilar motions may as it were be reduced to their faintest forms." This appears to be the earliest statement of the doctrine of the interference of light as being a canceling of opposing motions, afterwards developed by Dr. Thomas Young in explanation of the fact discovered in 1665 by Grimaldi, that under certain conditions, the combination of light from two adjacent sources produces not light, but darkness. In some respects, therefore, Swedenborg's doctrine of the ether is closely in accord with recent science. In others, however, it requires modification. Thus, he says (*loc. cit.*, article 16) "that the ethereal particles mutually press upon each other according to the altitude or weight of the superincumbent volume. That they press in like manner most equally in all directions." Also that the ether may be compressed into a small part of the volume occupied in its expanded condition, etc. We believe that ether becomes denser in the vicinity of gross matter, because there the velocity of light decreases, as if there were obstruction. Science also continued to treat the universal interstellar medium as if it were a gas highly rarefied, until within a few years the view has prevailed that the medium which fills the interstellar spaces has no weight, and is practically incompressible. The ether particles which are formed out of the aura by motion, appear to have perfectly definite dimensions as luminous particles, but may indeed be condensed in the interior of matter.

The passages in the work on *The Soul* in which Swedenborg says that "there are as many most delicate pulsations and touches as there are luminous rays" (n. 25), and that "the passage of rays or modifications of the ether is made in a spiral form" (n. 88), are not so distinctly in favor of an undulatory theory of light as might be imagined, since he is treating of the reception of light by nerve tissues; and here Newton himself uses language very similar to that of advocates of the undulatory theory, as when he says: "Do not the rays of light in falling upon the bottom of the eye excite vibrations in the *Tunica Retina*, which vibrations, being propagated along the solid fibres of the optic nerves into the brain, cause the sense of seeing?" (*Opticks*, third edition, London, 1721, Qu. 12, page 319); "Do not several sorts of rays make vibrations of several bignesses, which according to their bigness excite sensations of several colors?" (Qu. 13, page 320). Newton was also obliged to introduce his hypothesis of "fits of alternate easy reflexion and easy transmission," undergone by the luminous corpuscles, in order to explain the colored rings which he discovered and which are called by his name; and in treating of the diffraction fringes seen at the edges of bodies casting shadows, he says: "Are not the rays of light in passing by the edges and sides of bodies, bent several times backwards and forwards, with a motion like that of an eel?" (Qu. 3, page 313) which must not be interpreted as in any sense an endorsement of the undulatory theory of light

The doctrine of heat has passed through various imperfect

nd transitional stages, equally with that of light. At first
here was a tendency to regard heat as a substance, but now
here is no more doubt that, as Swedenborg taught, it is
nergy manifested as internal motion, a view which seems
o have been held by Newton who remarks on the action
f "light upon bodies for heating them, and putting their
arts into a vibratory motion wherein heat consists" (Qu.
, page 314). This view, however, was not commonly held,
ntil the experiments of Count Rumford, and the memorable
vork of Joule and others on the correlation of heat and
nechanical work, established it.

I will now give a summary view of Swedenborg's later
eaching in regard to heat and light by the following ex-
racts from the *Apocalypse Explained.* The translations,
xcept the parenthetical interpretations which I have intro-
uced [in square brackets], were made for me by the late
r. Samuel Howard Worcester, at whose suggestion I began
his study many years ago.

> **There are two mediate causes in nature, by which every effect,
> r production and formation there, is accomplished. These me-
> iate causes are light and heat. Light modifies substances, and
> eat actuates them, each from the presence of the sun in them.
> he presence of the sun which appears as light, causes activity
> f the forces or of the substances of every individual (part)
> or particle], according to the form in which it is from creation.
> his is modification (or variation and succession of modes). But
> e sun's presence that is perceived as heat, spreads the individ-
> al (parts), and produces a power (or force) of acting and of
> ffecting according to the form of those (parts), by actuating
> e conatus [i. e., by increasing the potential energy] in which
> ey are from creation. The conatus [or interior potential
> nergy] which by means of heat, becomes an [outwardly] active
> rce, even in nature's least forms, is from the spiritual that acts
> them and into them. (n. 1206).**
>
> **In the sun is pure fire. Outside of the sun, this fire is [mani-**

fested as] heat, decreasing as [the square of the] distance from the sun increases; and light is modification (variation of modes), or its interior action in substances which are outside of the sun and this also from its fire. (n. 944).

The ethers and airs give heat when brought into action in mass (volumatim actae) [i. e., when their activity as a whole is involved], but when modified as to single things (singillatim modificatae) [i. e., as to the special motions or configurations characteristic of their least parts], they give light. Hereby the su exercises all its power, and produces all its effects outside o itself; that is, by ethers and by airs, by means of heat and o light. (n. 726 II).

Light itself and heat itself are not material, but still they affect material substances, light by modifying them (or varyin their modes), and heat by changing their states. The light an heat which are from the sun of the world are natural, howeve because that sun is fire and not love. (n. 1131).

From the divine love of the Lord which appears in the angeli heaven as a sun, proceeds light and proceeds heat; the light i the life of His divine wisdom, and the heat is the life of Hi divine love. The spiritual heat which is love, and the spiritua light which is wisdom, flow-in into subjects which are recipient of life in the same manner in which natural heat and natura light from the sun of the world flow-in into subjects that ar not recipients of life. (n. 1134).

Auras and atmospheres which are spiritual because they ha existence from the Lord as a sun, when brought into action i common (communiter actae) [i. e., when acting as undifferentiated voluntary impulse], exhibit heat, and when modified a to single things (singillatim modificatae) [in the details of precise intellectual activity], they exhibit light. The heat which i its essence is love, and the light which in its essence is wisdo are specifically called divine truth; but taken with the aura they are called the proceeding Divine. (n. 726 II). This heat the good of love, and this light is truth from that good; a the two make wisdom and intelligence with the angels and wi men. (n. 709).

I propose first to give an account of some recent speculations and experimental researches in the domain of molecular physics, and afterwards to compare their trend with the most probable interpretation of Swedenborg's careful but very concise definitions, which being couched in general language require expansion and interpretation in their application to individual cases.

The "Correlation of Forces"

In 1885, Clausius, the great expositor of the modern doctrine of the molecular structure of matter and of the hypothesis that heat is molecular motion (we should now wish for a more explicit wording, but that will be shown later), delivered an address which marks an epoch ("Sur le rapport entre les grands agents de la nature." *La Lumière Electrique,* Tome 16, page 253, 1885). His subject was the intimate relation of the diverse natural agencies by which energy is manifested. In this address we have an excellent summary of the progress of scientific theory. Important modifications have been made in recent scientific doctrine, especially in regard to the nature of electricty, where the newer science is in remarkable agreement with Swedenborg's doctrine of the elementary particles, as we have seen; but the discussion of the great elementary principles of correlation was a notable advance in its day and still has sufficient merit to be worthy of preservation. It represents an imperfect view of that which Swedenborg has given with greater fulness in his doctrine of degrees.*

The undulatory theory of light, propounded by Huyghens, which postulated a universal medium with the fluid properties of a gas and the elastic properties of a solid, did not gain credence at first, owing to the ingenuity of Newton in devising secondary hypotheses to overcome the difficulties of a vastly more troublesome explanation. The brilliant verification of the undulatory theory as to essentials was left for the Nineteenth Century.

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* In what follows I shall dispense with quotation marks. My own parenthetical remarks will be perfectly obvious.

Melloni's discovery of qualitative differences in the invisible radiations from heated bodies, similar to the colors of light, and the discovery by Knoblauch that invisible radiations can be polarized and doubly refracted, precisely as in the case of light, established the identity of luminous and invisible radiations.

It was but a step from the undulatory theory of light, to the vibratory theory of heat; and now, says Clausius, of two agents primitively regarded as distinct—namely ligh and heat—there virtually remains but one, which, when confined to molecular particles, and defining the thermal status of a volume of matter, we call heat. It must be remembered that Clausius was thinking here in terms of energy which i one and the same under whatever form it may assume.*

The early experiments of Gilbert, (A. D. 1600), with static electricity, appeared to indicate a fundamental difference between magnetic and electric attraction.

Oersted's discovery of the action of an electric curren upon a magnet, and Ampère's demonstration that a smal circular electric current comports itself in regard to th forces which act between it and other currents or magnets exactly like a small magnet, have given rise to the science o electro-dynamics; and "magnetism" becomes a name used t designate a special electro-dynamic conception. Magnetism and electricity are thus, in a sense, reduced to a single agent, electricity.

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* We are not sure that Clausius was entirely free from th prevalent haziness which confounds "heat" with infra-red radiation; but since there is an obvious most intimate correlatio between heat and radiation of whatever species, we may giv him the benefit of the doubt and assume that he is speaking o the continually recurring transition between the two form of energy.

We might demur to the absoluteness of this statement in which Clausius slightly exaggerates. We admit that magnetism is an invariable accompaniment of a circular electric current. But distinctions have to be made.

Can we in a similar manner, correlate electricity and heat? Clausius maintains the contrary. In fact, he says, no one has transformed electricity into heat, or heat into electricity. An electric current consists of a continuous movement of electricity, which movement, communicated to the atoms of the body in which the electricity circulates, augments the molecular motion which constitutes heat. It is not, then, the electricity itself, but only its motion which is transformed into heat, or thermal motion. In like manner, when an electric current is produced by heat, it is not the formation of electricity which takes place, but only the putting in motion of the electricity already contained in the conductors. Thus heat is transformed into electric movement. These transformations do not therefore tell us anything about the essential nature of electricity.

If Clausius had been able to foresee the further progress of science, he would have recognized that neither is electric substance converted into magnetic substance, but that it is the *motions* of the two which are correlated.

On the other hand, a surprising fact has been made known, which permits the establishment of a relation between electricity and heat and light from another direction. On the assumption of the existence of an electric substance, consider the case of two electric particles of the same kind moving with equal and invariable velocities in parallel directions. They will exercise on each other an electrostatic repulsion and an electro-dynamic attraction. The first is independent of the velocity, the last, on the contrary, increases with the increase of the velocity. Consequently, we may ask what velocity the electric particles must have, in order that these attractive and repulsive forces may become equal and mutually destroy each other.

The answer given by the experimental researches of Weber and Kohlrausch is, that the velocity must be just equal to the velocity with which radiation, luminous or nonluminous, traverses the spaces of the universe. This and some other coincidences, show that electric forces are concerned in the propagation of light, a result to which Maxwell was led by theoretical considerations.

Clausius concluded that we must conceive the universe to be filled with electricity which he identified with the luminiferous ether. By this he meant the medium which fills all space, or what Swedenborg calls the magnetic aura, since, according to Swedenborg, the ether does not fill all space, a view which we are now prepared to accept. The speculative conception put forth by Clausius in regard to a universal *electric* medium is now overthrown by the discovery of the electric particle, or electron, and its segregation in limited and definite localities as the fundamental of matter.

Sir William Thomson was of the opinion that "we can scarcely conceive of light coming away from the sun with vibrations through much greater amplitude than 1/300 of the wave-length." With this proviso, and using Pouillet's value of the solar constant, he obtained for the mass of one cubic centimeters of light-bearing ether, 45×10^{-19} gram, in the immediate vicinity of the sun. Professor Maxwell repeated the computation for an amplitude three times as great, which gives $\frac{45 \times 10^{-19}}{3^2} = 5 \times 10^{-19}$ gram, although his actual figures are nearly twice as much, owing to a numerical mistake. These are estimates of a minimum value of the mass of a highly active body of light-bearing ether, since if a smaller amplitude be assumed, the mass of the ether will come out larger, using the same value for the mechanical equivalent of sunlight; and in the opinion of these physicists, it is not permissible to use a larger value of the amplitude.

In the Journal of the Franklin Institute for October, 1897, Luigi D'Auria attempted to compute the acceleration produced on a star by the attraction of a volume of the universal medium whose radius was assumed to be that of the stellar system. If ρ is the radius of a sphere of the universal medium, or aura, around which a star revolves in a circular orbit; σ, the density of this hypothetical substance; $R =$ 20,8880,000. feet = the radius of the earth; $D = 5.6$, its density; $g = 32.2$ feet = the acceleration of gravity at the earth's surface; v, the velocity, and T, the period of revolution of such a body, are given by the equations:

$$v = \rho\ (g\sigma \div RD)\ \tfrac{1}{2},$$
$$T = 2\pi\ (RG \div g\sigma)\ \tfrac{1}{2}.^{*}$$

Introducing a value for σ, D'Auria obtained, as he supposed, confirmation of his hypothesis that the attraction of the so-called "ether," whose possession of the quality of "mass" and "density" is here unwarrantably assumed (though it is to be noted that Maxwell's value related to a strongly *vibrant* ether which does have mass) is compatible with the observed proper motions of the stars. But in taking his value of σ

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[*] The equation of the pendulum, $T = \sqrt{l/g}$, connecting the time of a half vibration with the length and the gravity constant, must have the second member multiplied by 2 for a complete orbital revolution. Terrestrial g must be multiplied by the ratio σ/D. The superficial gravity increases as $\rho^3/\varrho^2 = \varrho$, that is, as the radius. Hence the ratio l/g does not change.

from Maxwell's computation, he failed to notice that b the mode in which it was obtained, this value was give in C. G. S. units. By assuming that the density of the ethe was referred to air, instead of to water, he introduced density nearly one thousand times too small. But Maxwell' estimate was already a minimum value, as we have seen and was wholly dependent on the luminosity of the ether and therefore was not applicable to a sphere of dark ether hence D'Auria's conclusion is of no value.

Moreover, if the estimated minimum value of σ be introduced in the equations, we get for a velocity of one millio feet per second, which is nearly that of the flying star 1830 Groombridge,

$$T = 1.64 \times 10^{13} \text{ seconds} = \tfrac{1}{2} \text{ million years},$$

$$\rho = 2.61 \times 10^{18} \text{ feet} = 84 \text{ light years},$$

a distance much less than the dimensions of the Galaxy but one which assigns an extraordinary attraction to the mere interstellar medium. As the computation takes no account of the attraction of the myriads of stars within a sphere of this radius, and as the mean velocity of the stars is very much less than this, while the value of ρ and the resulting mass of the entire aura must be immensely greater than that assumed, if mass be indeed one of its properties it follows that the actual velocities of the stars are incompatible with the possession of mass by the body of unilluminated aura which encloses them, since the least value which can be assigned to this mass, supposing its density to be identical with that of the highly illuminated ether near the sun (itself a vicious assumption), would generate stellar velocities far in excess of those observed.

Before attributing any attraction whatever to the aura, it is proper to eliminate the certain effect of the myriad of stars within the assumed boundary.

The known properties of the aura, considered as the medium within which gravitation and its potential energy reside, are so different from those of ordinary matter, that the universal atmosphere must be discrete from the aerial. In our conceptions hitherto, an insuperable barrier has separated these atmospheres. To correlate them, some intermediate was needed. This connecting link is at last supplied through the discovery of the atomic structure of electricity, which can now be demonstrated without reference to hypotheses as to the ultimate nature of electricity. It is safe to predict that the conception of atoms, which has already been so fertile in aiding the construction of chemical theories, and which has now been conjoined with Swedenborg's ideas of structure in elementary particles, will do as much for electrical science. The magnificent work of Professor (now Sir) J. J. Thomson on "The Conduction of Electricity Through Gases" and the immense but uncompleted structure of spectroscopic science, are foretastes of what we may expect from the further study of electrons.

The scheme of unification involved in the doctrine of the correlation of forces is still incomplete. The doctrine is capable of further extension. Already we have glimpses of a single (electric) substance out of which all the varied forms of matter have been developed. An atomic evolution comparable with that of the organic world. It becomes increasingly probable that the electron is this fundamental unit of natural substance—the most remarkable substance known, since it is not only formed out of the imponderable aura, but in its relation to matter possessing mass, it behaves like what we have been accustomed to call a "force," or to be more precise, as energy. In it, as in an egg or a seed, is the potency of future development. Thus mass is a form of energy and one more correlation must be made

—namely, that of matter and energy. Thomson's identification of matter and electricity, founded on Kaufmann's memorable experiment, has been reinforced in three lectures delivered at the inauguration of the Rice Institute by Sir William Ramsay, K.C.B., F.R.S., Professor of Chemistry in the University of London (Rice Institute Pamphlet, July, 1915), where the electron is treated as an "element." We have seen that it is, indeed, Swedenborg's "first element."

A DIFFERENT HYPOTHESIS AS TO THE NATURE OF ELECTRICITY

Swedenborg associated light and electricity: "There are minute corpuscles which resemble a kind of effluvia," (is he describing the brush discharge?) "and which are so small as to be able to move only a volume of ether. . . . If they are not spontaneously moved, but put in motion by means of the tremulation of the parts in any hard body where they are, then light is also produced, and also electricity, so long as the tremulation continues." . . . "The vibration of this body sets up in a similar way a vibration of the parts of the body, and of the minute corpuscles which are within it and float around it." (*Principia,* Chapter on The Ether, n. 21). Here and elsewhere, electricity is ascribed to a *tremulation* of corpuscles. With our present ideas, this seems to be a mistake. The corpuscles themselves are the electricity, when they are in a free state. Had he but known it, Swedenborg was already on the track of the true nature of electricity, when he described the vortical particles of his "first element." The tremulation is an unnecessary addition or at least an addition of only secondary importance. Nevertheless, even this idea has been revived in recent times.

M. Bourdin ("Lettre à Monsieur Clausius." *La Lumière Electricque;* Tome 16, page 419, 1885), speaking in behalf of a group of French electricians, took the occasion offered by the publication of the address by Professor Clausius, to oppose the conception of an "ether" distinct from aerial matter, and to advocate the hypothesis that electricity is a vibration whose phases are systematically irregular. The old "imponderable fluids," he said, are gradually giving way to "vibratory movements." Then why not include electricity? The only difficulty in the way of this has, heretofore, been the absence of a consistent explanation of facts. That proposed by M. Bourdin would apparently lead to mathematical expressions, similar to those already deduced. "Electric potential," instead of being likened to "head of water" in an aqueduct pipe, is interpreted to signify "the number of vibrations per second." Static electricity is assumed to consist of "superficial vibrations," which friction is often sufficient to produce; and dynamic electricity is attributed to profound longitudinal vibrations. An induction-coil increases the electric potential by summing up the vibrations produced, in the multitudinous distinct turns of the secondary wire, by the slower pulsations of the shorter primary. Considering a section of an electric conductor "one molecule thick," if the quotient of the electric energy divided by the number of its vibrations is too great for the size of the section, the amplitude of the molecular vibrations will exceed the limits of cohesion and the wire melts. The electricity will be "converted" into heat, a longitudinal vibration becoming a general thermal vibration, acting equally in all directions.

The unequal wasting of the carbon poles in the electric arc is attributed to the unsymmetrical or nonisochronous nature of the electric vibration. Other actions, such as those of the thermopile and dynamo, equally receive explanations; but nothing in the way of a crucial test, which might decide between the hypothesis of an electric atmosphere and that of an electric molecular vibration, is suggested by M. Bourdin. Great importance, however, is attached to the hydrodynamic experiments of Bjerknes, which show that a body may exercise either attraction or repulsion *according to its vibratory state.* These speculations were not sufficiently founded on facts, but they do have a certain basis in the evidence now forthcoming that the electron is a vortical motion in the aura, that it has definite periodic motion and hydrodynamic analogies, and more recondite relations with atomic vibrations.

Hydrodynamic Analogue of Magnetism

The hydrodynamic experiments alluded to by M. Bourdin (*loc. cit.*) are described by Géraldy in *La Lumière Electrique* (Tome 5, page 44, October 5, 1881). Bjerknes, by means of an apparatus composed either of pulsating drums, or of oscillating spheres immersed in water, succeeded in imitating most of the phenomena of magnetism and diamagnetism. For example, if a sphere suspended in water is heavier than an equal volume of the liquid, it is attracted by a pulsating drum; but if lighter, it is repelled. In the former case, its movement is smaller than that of the liquid, consequently, relatively to the vibrating body, it is of the same phase; but if it is lighter than water, the reverse is true.

Two bars, one lighter, the other heavier than water, suspended in that liquid, take equatorial and axial positions relatively to a pulsating drum, as diamagnetic and paramagnetic bars do when placed between the poles of a powerful magnet. Faraday attributed the difference between paramagnetic and diamagnetic effects to the difference between the attraction exerted by the magnet upon the body experimented upon, and its attraction upon the air. If the body is more sensitive to the attraction of the magnet than air, there is paramagnetism; if less sensitive than air, there is diamagnetism.

Again, considering the direction of flow in the circulating currents of an electro-magnetic coil, we find, comparing opposing faces, that magnetic poles, whose currents move in similar directions, attract each other; while opposing currents repel; and in the same way, surfaces of similar vibratory phase attract each other, while surfaces of opposite phase repel.

There is, therefore, a close similarity between certain magnetic and vibratory phenomena, which may furnish a clue to the most recondite problems of molecular physics.

THE EXISTENCE OF AN ETHER

Swedenborg avers the existence of an independent ether for the propagation of light, or a medium with particles much smaller than those of air. The weakest point of M. Bourdin's argument was undoubtedly that in which he attacked the hypothesis of the existence of a universal medium or ether," different from air. To this point, Clausius addressed a reply. Founding his argument on the kinetic theory of gases, he calculates that at atmosphere pressure, and at the temperature of the freezing point of water, the average distance between neighboring molecules of a gas must be 0.000003 mm. ($3\mu\mu$). This distance is very small, but it is still too great for the propagation of luminous waves through interplanetary space, where a density of 1/1,000,000 of an atmosphere would be too great for the existence of observed planetary motions. This density, however, corresponds to a molecular distance of 0.0003 m.m., which is already about the same as that of a wave of ultra-violet light ($300\,\mu\mu$), and is certainly exceeded in space. But it is inconceivable that a *transverse vibratory* movement should propagate itself regularly in a medium whose particles are more distant than a wave-length. Hence, the necessity of a universal magnetic medium, whose particles are in juxtaposition and can transmit the magnetic oscillations of the electro magnetic waves. The existence of the luminiferous ether rests upon that of the aura, but forms a distinct question to which we shall return.

We have seen that Swedenborg associates heat and light, but simply because heat is converted into light; and, conversely, a sufficient condensation of sunlight will generate combustion and heat.

Clausius, in treating of the correlation of forces, permitted himself to speak of heat as a molecular vibration and of light as an etherial vibration, and to virtually unite or identify the two; but in this laxity of definition, he obscured the fact that heat and light are very different modes of manifestation of the *one* only *energy* which underlies them. Swedenborg was careful to preserve this distinction.

In continuing his treatment of the subject of correlation, Clausius reduced magnetism and electricity to a single agent —electricity—thereby virtually ignoring the more universal element which underlies the electric one. Swedenborg's apprehension of this relation does not lose sight of a fundamental distinction.

Swedenborg had the idea that both light and electricity are produced by a tremulation of particles of ether.

More to the point is Max Planck's analysis of radiant energy and his determination of a least quantity, or "*Wirkungs quantum,*" for light, which is the measure of the energy in one of Swedenborg's ether-particles. To Swedenborg belongs the credit of having given a rational scheme of the structure of this entity. Planck does not attempt to do this, but his light-quantum is in no sense incompatible with the idea of a physical light-particle, or etherion, formed by motion out of the aura; and in its derivation it is associated with a least particle of electricity, so that Swedenborg's guess turns out to have been an uncommonly good one.

That wonderful substance, the aura, is the physical basis of all things in nature. Its perpetuity is a symbol and guaranty of a still wider continuity of existence in a spiritual world of causes. Energy, through its successive states as heat and as light, is continually being dissipated into the entropy of the aura, there to be preserved until it can be reëmbodied.

SECTION B

THE AERIAL ATMOSPHERE

The air we breathe, the atmosphere which enswathes the Earth as with a garment, the tender blue of far-off skies, the ravishing beauty of roseate dawns, beloved by artists whose pictures would lose a large part of their charm were it not for the subtle qualities which the whole fraternity calls "atmosphere," the varied paraphernalia of that never-failing topic of conversation—the weather, symbol of the spirit—"the wind bloweth where it listeth"—we cannot begin to name all that it means to us, all that we owe to this ever-present atmosphere. And yet, large and all-embracing as this ocean of air seems to us, the whole phenomenon is dependent on infinitesimal thermal motions in tiny invisible particles—the molecules and atoms of the air. These we must study.

Under atmospheres and their substance we read (in D. L. W., n. 174): "The natural atmospheres are discrete substances and least forms which originate from the Sun of the natural World and also receive the Sun singly and severally, and store up its fire in themselves." As to the aerial atmosphere we may ask: Do its least particles "originate from the sun"? The answer is: not momentaneously, but remotely they have thus originated in the sense that the entire Earth was once a part of the sun. Swedenborg's proposition on this point is the now accepted doctrine.

As regards the aerial atmostphere, however, when considered in respect to its peculiarly atmospheric properties, it is entirely true that without the heat derived from the sun's rays, the air would be frozen solid and would cease to be an atmosphere and to fulfil the functions of motion and life-giving medium. And since the sun throughout all of its substance is a purely atmospheric form, it may be said that the solid substance of our planet has been condensed from the solar atmosphere.

" Heat and Light go forth out of the Sun of the spiritual World, Heat out of the Lord's Divine Love, and Light out of His Divine Wisdom. . . . The Third which goes forth out of that Sun is the Atmosphere, which is the containant of heat and light. . . . This goes forth out of the Lord's Divine which is called Use." (D. L. W., n. 296).

This is said of the spiritual atmosphere. But in entire similarity we find that the aerial atmosphere of our globe is indispensable for the performance of those uses which make our planet a habitable world.

An atmosphere may be defined as an "aeriform" or fluid medium which receives energy in forms adapted to its structure and passes this energy on to other parts of the medium, or to the bodies which it encloses, and which it may serve either to nourish or to activate. It acts, therefore, either as substance, or as active force.

The natural atmospheres decrease in volume from the aura which fills all space, to the ether and air which are attached to individual globes. Hence Swedenborg says (in D. L. W., n. 302):

"Since Atmospheres in their progress toward lower things decrease, it follows that they constantly become more dense and inert, and finally, in ultimates, become so dense and inert as to be no longer Atmospheres, but substances at rest, and in the natural World, fixed like those on the earth that are called matters. As such is the origin of substances and matters, it follows, *First,* that these substances and matters also are of three degrees; *Secondly,* that they are held together in mutual connection by encompassing atmospheres; *Thirdly,* that they are fitted for the production of all uses in their forms."

And in n. 303 we are taught that, "as Atmospheres are prior things, whereby the spiritual Sun manifests itself in ultimates and as these prior things continually decrease in activity and expansion down to ultimates, it follows that when their activity and expansion come to an end in lowest things, they become substances and matters such as are in earths, which retain within them, from the Atmospheres out of which they originated, an effort and tendency * to bring forth uses. Those who do not evolve the creation of the universe and all things thereof by continuous mediations from the First, can but build hypotheses, disjoined and divorced from their causes, which when surveyed by a Mind with an interior perception of things, do not appear like buildings, but like heaps of rubbish."

"From this Universal origin of all things in the created Universe, each and every particular thereof has a similar order; in that these also go forth from their first to ultimates which are relatively in a state of rest, that they may terminate and become permanent. . . . There are degrees of both kinds [discrete and continuous] even in the least things of all, because the Spiritual Sun is the sole substance from which all things are." (*Ibid.*, n. 304).

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*Or a force and energy pushing towards the performance of uses.

The teaching of the *Principia* that the aerial atmosphere consists of least particles within which there is structure in discrete degrees, is reiterated, and this position is now fully confirmed by science; but the precise form of an aerial particle is not defined in the passages just quoted. Here the revelation of spiritual principles from a higher source ceases, and we are left to our own devices to determine the precise forms of motion according to the experimental evidence. We have seen that the *Principia* is such an attempt to follow nature into her inmost recesses, and that in many respects it is a remarkably successful attempt. How is it in respect to the air particle?

According to the *Principia* doctrine, the aerial atmosphere is made up of particles in contact, which have the spherical form. The surface of each particle is composed of other much finer particles, also in contact and comparatively quiescent or passive, forming a surface pellicle which is kept distended by the motion of interior actives. When fully distended, the surface pellicle consists of a single layer of finiting or limiting particles, but under compression these are forced inwards and are several layers deep. This hypothesis we shall proceed to examine in detail.

In treating of the "first element" (*Principia,* Part I, Chapter VI, n. 14) it is expressly emphasized that the particles are "contiguous."

Coming to our author's theory of the "ether or third element" we read (*Ibid.*, Part III, Chapter V, n. 16): "The ethereal particles mutually press upon one another according to the altitude or weight of the superincumbent volume."

Physics still attributes differences of "density" to the ether within refractive bodies, though this density is found to vary with some (possibly electrical) attraction of the enclosed atoms, and not with any linear dimension. The point to be observed is that Swedenborg makes the particles "mutually press upon one another," that is, they are in contact. The means by which the particles are forced into contact are not expressly stated; but the result in the contraction of the individual particles is described in n. 19: "Under some degree of compression" the particles are condensed. Some of the superficial finites are driven inwards, and the particles become smaller under pressure. Like their predecessors, the first elementary particles, these ether particles of the permanent ethereal atmosphere attached to an earth, are supposed to be "contiguous." Without mutual pressure and contiguity the particles could not be condensed, because, being perfectly elastic, they would immediately expand when pressure is released.

As to the air particle we read (*Ibid.*, Part III, Chapter VII): "Since the ether and air particles are similar to each other and differ only in dimension, all the qualities of motion and figure of the ether particle are applicable to the air particle." This includes the "contiguity" as an attribute of the aerial particles. Thus in n. 13 it is said: "The air particles reciprocally press upon one another according to the altitude or weight of the incumbent volume." And in n. 15 we are told that "when the air particles move in volume, they nevertheless preserve equilibrium among themselves, and remain in their relative positions." By no possible interpretation can this language be reconciled with the modern kinetic theory of gases, where the air particles are treated as widely separated and as continually *changing* their relative positions. By n. 9 we are taught that air particles when free to expand to "their highest degree of expansion" (evidently meaning that the particles are supposed to be released from mutual pressure) "undergo disruption and cease to be elementaries." In this case their finites "must immediately pass into the surfaces of the neighboring particles to exert pressure, the free particles must be disrupted, that is, widely separated particles formed on this plan are impossible. But in fact and in conclusion, we know that the air particles are not destroyed by the utmost expansion in a nearly perfect vacuum, but are found in perfect form as a minute air bubble when the vacuum-chamber is filled with mercury. Also excessively rarefied gases in the tails of comets continue to show their characteristic spectra. Hence it follows that Swedenborg's air particles have no existence.

Again, Swedenborg's idea that the expansion of a gas is not due to the motion of its particles but to the internal expansion of each least particle, leads him to make some extraordinary statements which cannot be admitted. In n. 8 he says: "Even without motion [we have seen that *with* motion the particles burst] they [the air particles] may be expanded, and in this state of expansion, produced without motion, they are not rigid but elastic; the greater their expansion and rest, the more elastic and yielding are they; while the greater their compression the less their elasticity." Reference is made to Part III, Chapter V, n. 10, and to Part I, Chapter V, n. 31, from which it will be seen that by "highly elastic" Swedenborg means "highly impressionable," and this is a property best exhibited when the particles are expanded to their utmost. But today we admit that the air particles are always expanded to their utmost and are always free, except at moments of collision. By elasticity we understand the power of restitution of the shape of the particles and thence their rebound after contact deformation. While the gaseous state is preserved, the elastic force grows *greater* as compression increases. This is the opposite of Swedenborg's statement.

Elastic deformation may be either an expansion, a contraction, a twist, or a bend;* and the elasticity, say for a bend, may be very great within narrow limits, as in glass, or comparatively small but with very wide limits, as in rubber. With the definition that elasticity is power of restitution after deformation, we refer the elasticity of the air to the power of restitution of shape which the air particles have after distortion by collision. Swedenborg also (*Ibid.*, n. 5) attributed the elasticity of the air to forces within its particles: "The air particle thus formed and equilibrated is highly elastic and is properly called elementary. It owes its elasticity, however, to the enclosed first and second elementaries, in which the primitive elasticity is latent." No exception can be taken against this statement. It harmonizes with the modern idea. But owing to his adoption of the incorrect notion that there is always contiguity between air particles, he thinks there may be loss of elasticity in air particles by compression. Here apparently he has become confused by considering what happens in liquefaction when the particles do come into permanent contact, and gaseous elasticity is no longer exerted because the gaseous state has ceased. Something similar takes place in individual atoms when they part with internal energy in the course of atomic evolution (*cf.*, for example, the increasing difficulty with which the substances of smallest atomic volume can be melted). But the elasticity of the individual particles of the air is not changed by compression. Indeed, owing to the more numerous collisions in the compressed gas, the number of such elastic restitutions in the units of volume and time is increased, and the display of energy is likewise increased. Swedenborg, who supposes the particles of a condensing gas to have been contiguous all along, postpones the liquid state until the central lumen of the particle has been filled with bullae from the entrance of the superficial finites into the interior with great reduction in the volume of the particle under liquefaction pressure. Today we may be certain that this reduction in the volume of the particle by simple pressure in liquefaction does not take place. Whether there may be some such reduction of atomic volume in atomic evolution is a wholly different problem. In general, the interior electrons in an atom are revolving with such enormous velocity that this internal motion cannot be changed appreciably by the relatively slight deformation communicated to the particle by thermal shocks. The thermal shocks may transform the shape of the internal electronic orbits temporarily, or cause their planes of orbital revolution to oscillate slightly, and may thus give rise to a special internal thermal motion in addition to the external one which concerns translation of the particles and its variation, but this variation of the motion within the particles does not alter their volume appreciably. From the equation for gamma, the ratio of specific heats,

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* A spherical atom, colliding centrally with another atom will have its diameter in the line of impact shortened and the diameters at right angles to this direction lengthened. The distortion thus produced will oscillate between oblate and prolate spheroidal forms until the spherical form is restored. Here contraction in one direction is immediately followed by expansion in another direction and the total volume of the particle is not much altered.

$$\gamma = 2/3\frac{J_u}{J} + 1 \text{ (\textit{Cf.} Section E, page 348),}$$

we see that if the action of heat upon a gas were merely to increase the central motion of its particles (which is Swedenborg's proposition: "Heat is thus a most intense central motion of the parts of air or ether," (*Principia,* Chapter on "Fire," n. 10) J_u would be zero and the value of γ would be unity. Since γ (the ratio of the two specific heats) never does have this value, this alone overthrows Swedenborg's supposition that the air particles are contiguous and that heat is simply a *central* motion in these particles. Hence if the energy communicated to a gas by heat were immediately transformed into motion within the particles of the gas, and if the expansion of the gas by heat were due entirely to this process, there should be no difference between the specific heat of a gas at constant pressure and its specific heat at constant volume; whereas the difference between these two specific heats (and thence their constant ratio) is one of the fundamental facts of thermodynamics.

One other point must be noted in respect to the interior constitution of Swedenborg's ether-particles. In the chapter on the ether (n. 5) we are told that "in the case of the ethereal particle, as its greatest motion is at the surface, it is, consequently, more compressed at the surface and more expanded at the center. Now because this spherical composite body is moveable not in one direction but in all, it follows that the ethereal particles accommodate themselves to all. There is also a certain centrifugal force which urges them from the center to the circumference, and if the motion be equal in every direction, the elementary particles [component interior particles] are driven to assume a more erect position towards the surface." Here mention is made of centrifugal force, but in n. 19 the interior elementaries are said to be placed "according to their poles from the center to the surface." The figure given also shows them placed in radial rows. And in n. 10 it is stated that "in a state of motion the enclosed elementary particles arrange themselves from the center to the surface, and take an erect position like radii or crests, by the application of one pole to another, in consequence of which they become harder and more resisting. . . . For if each enclosed particle fits one of its poles to the pole of another, then the one rests, as it were, upon the other, and the one being thus supported, as it were, by the other, offers resistance. In regard to their poles they are not yielding as they are in regard to their equators.

Moreover, in consequence of this arrangement of the particles, they adapt themselves to a kind of vortical motion; that is to say, to every motion which takes place reciprocally among themselves, and into which they cannot enter without first taking their natural arrangement." Here the radial arrangement is regarded as the "natural arrangement," and the "vortical motion" specified is that of radial vortex filaments *inside* the particle. In n. 11 also the statement is explicitly made that "if the enclosed elementaries expose their equators to the surface, or if they experience a pressure in the direction of their equators, the most yielding and highly elastic particles recede into themselves."

We can neither affirm nor deny these hypotheses in respect to the constitution of a particle of the earth's ethereal atmosphere, but when all this speculation is transferred without change and applied to the constitution of an air particle, that is, to the atom, we are on ground where modern experimental evidence can be obtained, invoking which, we find it more reasonable to attribute the inertia of an atom to the resistance to change in orbital revolutions of interior electrons; and we find in the centrifugal pressure of these revolving electrons a sufficient cause for the maintenance of a spherical shape and for resistance to deformation, when it is known that the revolutions are made at tremendous speed. In brief, we find it more reasonable to substitute circular strands of vortex-particles, juxtaposed by their poles and possessing gyrostatic inertia by virtue of both rotation and revolution, instead of rigid radial strands of such particles. We do not deny that inertia might be given by the merely vortical motion of fixed individual electrons, set in rigid rows; but the spectroscopic evidence favors orbital revolutions, or perhaps in some cases oscillations of electrons along circular arcs as generators of line-spectra, and this points to orbital revolution as a basic feature of atomic structure. Vortical motion will not explain line-spectra.

Under certain special conditions of high electrification, air particles appear to cease their play of irregular motion and to become contiguous particles, moving consecutively along definite streams, but this condition is a temporary and peculiar one. For example, when, in some of the older X-ray tubes the vacuum became too high, it was customary to restore a little gas to the tube by heating an attached regulating bulb. According to our ordinary conceptions under the kinetic theory, we should have expected that the liberated gas particles would immediately rush in all directions to fill the space of the vacuum chamber. Nothing of the sort takes place. Instead, if the tube be viewed in the dark, we see luminous dendritic or reticulated threads of something which behaves like a viscous substance, something which hugs the walls of the receiver and creeps slowly over their surface. Apparently the particles of gas have ceased their ordinary thermal interplay. They have become polarized and are arranged temporarily in columns, which implies that they have poles formed by revolution. But this has nothing to do with the ordinary behavior of a gas under atmospheric form.

We cannot find space for anything like a complete presentation of the kinetic theory of gases, but certain parts of the theory of moving and colliding air particles and of the nature of the inner elastic energy of these particles, may be considered in their relation to Swedenborg's hypotheses.

THE KINETIC THEORY OF GASES

The supposed necessity for the hypothesis that a gas consists of minute molecules separated by relatively wide intervals, and that these molecules move about with occasional collisions, the energy of molecular deformation constituting the sensible heat of the gas, is thus shown by Maxwell:

The force which produces the expansion of a perfect gas, must, by Boyle's law, vary inversely as the distance of the component particles; but if this force were due to a mutual repulsion of the particles, it should vary inversely as the square of the distance, as shown by Newton. A very slight deviation from Boyle's law which is observed in most gases, is consistent with the existence of slight attractive forces between the molecules; but this secondary effect is so minute that it indicates, on the kinetic hypothesis, a wide separation of the molecules, relatively to their dimensions.

A fundamental property of gases and vapors is formulated in Dalton's laws of elastic force in mixtures. These laws are as follows:

1. The pressure, and consequently, the quantity of a vapor which will saturate a given volume at a constant temperature, remain the same, whether this volume contains a gas or is empty.

2. The elastic force of the mixture is equal to the sum of

the elastic forces of the gas and vapor, the gas being referred to its original volume.

The second law is really embraced under the first, but is usually stated separately for greater clearness. The apparatus by which these laws may be demonstrated, is due to Gay-Lussac. It consists of a glass U-tube with graduated branches of large and small calibre respectively, furnished with stop-cocks at the top and bottom of the larger branch. The height exceeds that of a mercury barometer. The apparatus being filled with mercury, the upper end of the large tube is connected with a reservoir containing the pure gas. The stop-cocks are opened and enough mercury is allowed to run out to partly fill the tube with gas. Upon closing the cocks, mercury is poured into the small branch until the level is the same in both branches. The gas is then at atmospheric pressure. If now the liquid to be vaporized is introduced into the gas, drop by drop through a special stop-cock which has a one-sided cavity just large enough to hold a drop of liquid, the volume of mixed gas and vapor increases until the space is saturated with the vapor of the liquid. There is then a difference of level between the mercury in the two branches. By addition of mercury in the small branch, the level in the large branch is brought back to its original height. The volume of the mixture is therefore the same as that of the single gas at the first, and the height of the differential mercury column (f) measures the vapor-pressure which is not increased at the given temperature by any further addition of liquid, that is, the liquid ceases to evaporate.

The second part of the experiment consists in filling the apparatus with mercury and letting enough run out at the lower stop-cock to make a vacuum in the inner chamber. The difference of level then measures the atmospheric pressure (p). If drops of liquid are now introduced as before, the level of the mercury in the inner chamber falls, until, when saturation is effected, the depression of the mercury column is precisely equal to the excess of pressure in the former case. In the first experiment the total pressure is $p + f$, in the second it is f, since we have made $p = 0$. Hence it is possible for two or more gases to occupy the same space without interfering, which proves that their particles must be very small, relatively to the space that they fill. If the number or quantity of the gases in the mixture is greatly increased, however, so that the pressure is great, the molecules no longer have sufficient freedom of motion to maintain the absence of mutual influence demanded by either Boyle's or Dalton's laws.

Since a gas may be indefinitely expanded, continuing all the time to exert a pressure on the walls of the containing vessel, we must either suppose that the particles are individually expansile, or that they are moving among themselves and are pushed apart by the pressure of their innumerable impacts. The latter hypothesis is found to agree with the facts given by the preceding experiment. This definitely disproves Swedenborg's hypothesis that the particles of air expand or contract so as to be always in contact, and yet fill to repletion whatever volume they may assume. Figures are drawn by him representing a supposed duplication or triplication of the finites in the retaining wall of a particle, attending the variation in volume. These lose their value with the present proof that gaseous elasticity is not produced thus. This point is so important that I must establish it beyond all possible doubt.

According to Avogadro's law, equal volumes of any gases whatever, taken at the same temperature and pressure, contain equal numbers of molecules, although the masses of the individual molecules may vary in the ratio of one to many hundreds; hence it follows that the volume occupied by the gas is determined not by the size of its particles, but by the distance between them; and this distance depends on the vigor of their movements, that is, on the temperature of the gas. Near the temperature of freezing water, each air molecule suffers something like $(10)^{10}$ collisions every second. The pressure (p) upon the unit of surface of a receiver filled with a gas whose molecules have a given mass (m) and move with a mean velocity ($l/t = l$), *i. e.*, with a length of path, or distance traversed in unit time $= l$, depends on the number of molecules (n) which strike the unit of surface in the unit of time, and on their momentum (ml), and is equal to the momentum destroyed and restored by the elastic rebound every second, or $p = 2\,n\,m\,l$. The velocity (l) increases with the temperature, but is constant for a given temperature at which the pressure is proportional to the number of molecules in the unit of volume, or to the density of the gas. As the density is inversely proportional to the volume occupied by a given mass of gas, the pressure on unit surface at constant temperature is also inversely proportional to this volume. Hence if the pressure is due solely to molecular motion, the pressure multiplied by the volume (pv) is constant at a given temperature. But this is Boyle's law.*

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* Daniel Bernoulli in 1738, or shortly after the publication of Swedenborg's "Principia," proposed the doctrine that pressure in gases is due to the impact of their moving particles. And in 1750 Michael W. Lomonossoff, after showing that the pressure of a gas on the kinetic theory ought to be inversely proportional to the volume occupied by unit mass, foresaw that this relation would no longer hold at high pressures, because the volumes of the particles themselves would not change and therefore could not be neglected. The demonstration that in fact this is so, was left for Van der Waals in 1873.

Regnault found that if an initial volume (v_0) be reduced by pressure to $v = \frac{1}{2}v_0$ (to accomplish which the initial pressure, p, must be increased, if Boyle's law is correct, to $p = 2p_0$), there is approximate agreement with the law $pv =$ const.; but that the law is not exactly followed, the ratio ($p_0 v_0 \div p v$) differing from unity by a few thousandths in the case of the more permanent gases. This deviation was to be expected, owing to the mutual action of the molecules during their nearest approach; but since the difference from unity is very small, the time during which the movement is free from interference, or the duration of the mean free path, must be large relatively to the duration of a collision. The dimensions of the molecules have been calculated in a variety of ways, all in substantial agreement. Clausius obtained for the diameter of the molecule of carbon dioxide, 1/3,000,000. of a millimeter, and for the mean free path at zero degrees Centigrade, and atmospheric pressure about 180 times this distance. A further confirmation of the order of magnitude of molecular dimensions, is obtained from experiments on the compression of gases. A volume of hydrogen at normal atmospheric pressure is reduced to 0.001 of its bulk by a pressure of 3,000 atmospheres. At this very great pressure, there are indications that we are approaching the dimensions of the space occupied by the molecules themselves, or that the free path has become small, relatively to the diameter of the molecule. Under these circumstances, the product (pv) has increased to $3 \times (p_0 v_0)$. The conditions begin to approach those of liquids which are almost incompressible, so that v is nearly constant, and pv varies nearly proportionally to p.

At low pressures, increase of pressure diminishes the product (vp), because the particles are forced nearer together and remain under the influence of mutual attraction during a relatively longer time. The attraction of the internal parts pulls the volume together, or makes it smaller; but above a certain pressure the opposite effect prevails. With collisions of increasing frequency, molecular deformations and elastic reactions are greater, the particles are more and more vigorously repelled, and the volume becomes relatively larger. Thus the isothermal pressure-volume lines, plotted wih pv for ordinates and p for abscissas, which ought to be a system of straight lines parallel to the axis of p, if Boyle's law were rigidly followed, are actually curves convex to the axis of p, with minima which are more pronounced at low temperatures. At low temperatures, the vaporous stage of simultaneous existence of liquid and gas, that is, of partial liquefaction, is reached. Hydrogen which is far from its temperature of liquefaction, has barely the faintest indication of a tendency to a minimum at low temperatures and pressures. Its molecules are of so small a mass that from the first beginnings onward to the end of compression, the elastic deformatory forces prevail over those of attraction.

Let us next consider the changes produced in the laws of gases by heat. Boyle's law and the increase of pressure with temperature may be expressed by the equation $pv = RT$, where T is the absolute temperature, and R, under the conditions in a closed vessel, is a constant of proportionality depending on the system of units employed. The mutual attraction of the molecules is proportional to the product of their masses. If there are twice as many molecules in a given volume, their mutual attraction will be four times as great, or will vary as the square of the density, or as the inverse square of the volume. The increased value of the pressure, due to this attraction, may be denoted by

$$p + \frac{a}{v^2}$$

The effective volume of the molecules, or the space throug which they exert a sensible elastic pressure in consequenc of their deformation when struck, has been found to b $4 \times \sqrt{2} \times v_m$, where v_m is the volume of a molecule. Denoting this effective volume by b, it must be subtracted fror v to give the volume within which the free movement take place, $v - b$. Substituting these quantities for p and v in th expression for Boyle's law, gives Van der Waals' equation

$$\left(p + \frac{a}{v^2}\right)(v - b) = RT.$$

Writing this as a cubic in v, we have

$$pv^3 - (bp + RT)v^2 + av - ab = 0.$$

Every cubic equation may have either one or three real roots Hence this equation will give "either one or three real value of v for any given condition of temperature and pressure. The interpretation is as follows: In 1863, Andrews discovered that above a certain critical temperature, it is impossible to liquefy a gas. At the critical temperature, th densities of a liquid and of its saturated vapor are the same The meniscus defining the surface of the liquid also vanishes because surface-tension ceases to exist, and flickering movements indicate that the liquid and gas intermingle freely.

Below the critical temperature, the gas becomes a vapo and can be liquefied by pressure. On attaining the liquefyin pressure, there is a steady diminution of volume until liquefaction is completed. If we draw curves with pressures fo ordinates and volumes for abscissas, the transition fron vapor to liquid below the critical point is denoted by a sudden inflection in the volume curve, followed by a horizonta stretch of continuous diminution of volume without increas of pressure, and then by a sudden resumption of pressure change. Professor James Thomson suggested that the liquid and vaporous branches are connected by a continuous curve of double curvature, representing the fact that it is possible to have superheated liquids and supersaturated vapors, although these conditions are unstable. For such a curve there are three real values of v, corresponding to a given value of p, within the liquefaction range; but outside this range only one value is permissible. This, therefore, is the interpretation of the above cubic equation. At the critical point we see from the volume curve for the critical temperature, that the three values of v have become one. At lower pressures, the process of liquefaction may be expressed by the equation

$$(v - v_1)^3\, p = \mathrm{x},$$

where vl is the portion of the volume which has become liquefied, $(v - vl)$ is the part not yet liquefied, the exponent expresses the fact that observation suggests that the process may be expressed by a cubic equation, and p is the pressure. At the critical pressure, p_c, and critical volume, v_c, the distinction between liquid and vapor having vanishd,

$$v - v_1 = v - v_c = 0,$$
$$(v - v_c)^3\, p_c = 0.$$

Developing by the binomial theorem,

$$p_c v^3 - 3v_c p_c v^2 + 3v_c^2 p_c v - v_c^3 p_c = 0.$$

By Van der Waals' equation,

$$pv^3 - (bp + RT)\, v^2 + av - ab = o,$$

we have:

$$3v_c p_c = bp_c + RT_c,$$
$$3v_c^2 p_c = a,$$
$$v_c^3 p_c = ab;$$

whence

$$v_c = 3b,$$
$$p_c = \frac{a}{27b^2}$$
$$T_c = \frac{8a}{27Rb}$$

From Regnault's experiments on the compressibilty of carbon dioxide, Van der Waals determined the constants in hi equation for unit pressure = 1 atmosphere, and unit volum = volume occupied by the gas at zero Centigrade and uni pressure, obtaining:

$$TR = 273R = 1.00646,\ a = 0.00874,\ b = 0.0023.$$

These values introduced in the equation for the critical temperature give $T_c = 32^\circ.5$ C. Since Andrews found the sam by experiment to be $30^\circ.92$ C., the agreement is certainl very close, considering the complex nature of the theory Some improvements in the theory have been made by Clausius, who showed that the pressure correction (a/v^2) varie with the temperature on account of the increase of viscosit with rising temperature. Even with this additional complication, however, the theory is not complete. The temperature of a gas being the sum of the kinetic energies of it molecules divided by their number, may be very differentl constituted according as the limits of *variation* of molecula velocity are wide or narrow. Radiation and absorptio within the gas need also to be considered. Moreover, th volume of a molecule, though it is nearly constant, is no absolutely so. Where the atoms in a molecule are revolvin around their common center of gravity, higher temperatur may produce more rapid spin and this by centrifugal forc will increase the *molecular* volume. On the other hand monatomic helium has its *atoms* condensed at higher temperature through the more powerful hammering which the then undergo. These variations of atomic and molecula volumes, however, are minute compared with the volume-variation of the total complex, due to change in the separation of the particles.

In my work on "Atmospheric Radiation" I have shown that, owing to the specially large self-absorption of its own radiation by a gas, the radiating layer is comparatively shallow. Within a large mass of gas, heat is transferred successively from one set of molecules to another by radiation and absorption, many times repeated, before the outer confines of the mass are attained and free superficial radiation results. In my paper on "The Radiant Properties of the Earth from the Standpoint of Atmospheric Thermodynamics," I have shown that the gradient of density in the upper air is determined almost wholly by radiant exchanges between the air molecules, on which the radiant potential depends.

The mechanism of radiation is variously constituted. "Prof. A. A. Michelson finds that rarefied hydrogen gives out its characteristic spectrum under the action of an electric discharge at a remarkably low temperature. The width of a line having been proved to increase, as the temperature rises, in the ratio of the square roots of the absolute temperatures, the width of the red hydrogen line in an unheated tube was found to correspond to a temperature not more than 50° C. above the surroundings, or 320° absolute. The emission of visible radiations at such a low temperature implies that the rays are not produced by simple heating (*i. e.,* molecular motion, or rectilinear motion of free ions [and their collisions]), but that the passage of the electric spark by ionic motions increases the motions (either rotations or oscillations) within the molecules, modifying the internal atomic [and electronic] motions without changing the [molecular] rectilinear velocities of the atomic aggregates to any great extent. On the contrary, since hydrogen and other simple gases may be heated to very high temperatures without causing them to emit visible radiations, it is evident that the shocks produced by external collisions, due to rectilinear motions, are not as efficacious in setting up internal atomic vibrations as are the torsions experienced during the passage of a spark. The aurora is a case in point In the middle latitudes it occurs usually at heights exceeding 40 miles, where the air is intensely cold, and is an instance of visible atmospheric radiation produced, not by direct thermal means, but electrically." (F. W. Very, *Atmospheric Radiation,* page 117.)

A free molecule does not radiate, except as its internal electrons may be disturbed. Mercury vapor at room-temperature and a pressure of 0.001 mms., under the influence of the powerful ultra-violet mercury line ($\lambda = 2536$), gives out strong resonance radiation of the same wave-length. At greater pressures, scattering and secondary radiation are less, but true absorption, and conversion of radiation into heat, take the place of resonance. A free molecule possesses the momentum of local mass-motion ($m\ l/t$), and it also has an internal energy associated with the movements of component atoms and electrons; but externally there is nothing of this inner energy to show unless momentum which has been overcome gives thermal energy in molecular collisions, or unless some of the revolving electrons within the atoms are overturned, in which case electromagnetic radiant energy appears. The latter must be distinguished from the inherent energy of the electrons; but inasmuch as the light-bearing ether has momentum, and therefore mass, elsewhere associated with the gravitational pulsations of electrons, it is probable that the ether particles also pulsate, which they must do if they present a *complete* image of electronic motion

There are, however, two sorts of radiation, namely: Thernally produced radiation, equivalent to the energy of moleular collisions involved in its emission; and electrical radition, or luminescence. The first is attributable to the nergy exhibited when the mass-giving electrons have their notion changed mechanically throughout the whole atom by ollisions. The second arises from electric perturbations of he oscillatory, or revolutionary, movements of single elecrons within the atoms, either with or without attendant high emperature. Luminescence of short wave-length, requiring notion of high speed for its production, may be given out y matter in which thermal temperature, measured by the nean square of molecular velocity, is very small, as we have ust seen. Sometimes only a few relatively free electrons re disturbed. At other times, as in the resonance of iodine apor, all of the electrons in the spherical shells, at least in he outer ones, are disturbed, each ring gives a band comosed of fine lines, each line corresponding to an individual lectron, and the different bands being harmonically related ccording to their latitude. A certain amount of freedom, owever, is required for this line resonance because where ne iodine vapor is ionized, or reduced to single atoms, these, ke the helium atoms mentioned above, are so hammered y collisions that they become compact and resonance ceases.

Molecular velocity always means relative velocity, because nis is the only velocity that we can change. The temperaure of a mass of gas may be reduced nearly to the absolute ero, but it may still retain a *potential* temperature of several nillion degrees by reason of the orbital momentum of the arth which is beyond our control. In like manner, we can ot control the essential electronic motions whose energy nakes matter, except in some minute extent in certain little-nderstood radio-active transformations.

SECTION C

NATURE OF ENERGY AND ITS RÔLE IN ATMOSPHERIC PROBLEM

Thus far, the evidence for the molecular structure o matter, and the conception of energy, or the power of performing work, as connected with the movement of matter or of something out of which matter is formed, have gained increasing strength; but the theory is by no means complete A powerful argument by Hirn gives an interpretation of th facts somewhat different from the prevalent mode of scientific thought. The conservative side of Hirn's statement however, is very strong. As he points out, the laboriou computations of the mechanical theory of heat are no wasted, but remain true under *any* rational conception. Al the change that is needed, is a new interpretation of thei meaning. And the new interpretation which Hirn suggests is very interesting to students of spiritual philosophy, fo it is, at bottom, a spiritual interpretation. It does not den one iota of material *appearance*, but points to a source deepe than matter for its explanation. The paper by Hirn,* entitled: *The Conception of Energy in Modern Science*, deserves a careful analysis. It supplements that of Clausius already cited, both together constituting an admirable exposition of the best scientific philosophy at the close of th Nineteenth Century. The principal points in the discourse o Clausius are these:

1st. The almost certain identification of agents formerl considered distinct, and the reference of others to thei proximate parentage.

2nd. The pointing out the impropriety of a prevalent expression and the showing that heat can not be *transforme* into electricity, any more than it can be into gravitation

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*Hirn: "La notion de force dans la science modern." (Extrai de la Revue Scientifique.)

3rd. The deduction that the entity which vibrates lumin-
usly, or which produces thermal motion, is no other than
lectricity itself.

The last two points are controverted by Bourdin, who,
owever, damages his case by the denial of any subtler form
f matter than the aeriform. The third point is fully sus-
ined by the discovery that, internally, matter is nothing
ut electricity.

M. Hirn considers that the existence of energy as a
pecific element of the universe is tacitly affirmed in the
ddress of Clausius. Two electric particles of the same
ind, in a state of repose, repel each other; but no action
t a distance can take place through an absolute vacuum;
iere must then be *something specific* which puts them in
onnection, and this something is the *element energy*, with-
ut which no phenomenon in the universe can be logically
xplained. The exposition of Clausius marks the transition
rom the past to the present. The affirmation of the exist-
nce of energy, as an element of the universe, will mark the
ansition from the present to the future. In his celebrated
ictionary, Littré has indicated thirty-two distinct and some-
mes opposite meanings to the word "*Force*" (energy); but
mechanics the word takes a more limited signification,
esignating the cause, whatever it may be, of the movements
f material bodies, either as a whole or in their least parts.
cience hitherto has merely predicated the urge without de-
ning it. Two distinct and opposing views of the nature of
iergy may be taken:

"1st. The movement of matter can only be born from
n anterior movement of an other part of matter and only
y immediate contact of matter with matter."

"2nd. The movement of matter is never born directly and
y immediate contact. It always arises from the action of

an element specifically distinct from matter, whether this element is otherwise separable or not."

The first of these two propositions has the majority of adherents to-day. Modern science imagines that it has accomplished a simplification and a progress by substituting the movement of matter in the place of mysterious and incomprehensible "energy"; but it is easy to see that the former has been deduced from an isolated, exceptional phenomenon which has been imperfectly analyzed, and then extended and generalized by the aid of hypotheses. We meet with two orders of physical phenomena; the first effected by the shock of one body against another, from the violent impact of wind and wave to the milder ones of our youthful games; the second, where movement appears or disappears without any other movement being visible which can explain the fact. The fall of a body whose support is withdrawn, and the progressive increase of its motion; the recoil of a stretched spring; the sudden expansion of exploding gunpowder; the oscillation of a magnetic needle, disturbed from its position of equilibrium;—these are examples of the second order of movements which includes a great majority of all physical phenomena; and yet, strange to say, the exceptional cases have been made the standard by which all the others are to be explained! It is supposed that the shock of invisible material molecules or atoms will account for the transfer of motion between bodies not apparently connected. Let us see how this doctrine bears the test of comparison with observation.

According to Lesage's theory, gravitation results from the impact of myriads of propelling particles which every atom of matter is continually emitting, bodies face to face being partially shielded in the line joining their centers and being thence pushed towards each other by the resultant of all the impacts. Two facts annihilate this theory—First: Laplace has shown that gravitation, if it does not act everywhere at once, must have a velocity at least 50,000,000 times as great as light. The necessary velocity of the propelling particles being really infinite, no such propagation exists. Here I am following M. Hirn who places his faith in Laplace's argument. In my opinion Proctor has given a much more forcible demonstration that the velocity of light is greatly surpassed by that of gravitation. I shall return to this in another connection. Second: Since the number of impacts which each atom receives depends upon its surface, and since the density of platinum is 36.4 times that of lithium, we must conclude, from Lesage's theory, either that the unit of volume contains 36.4 times as many atoms of platinum as of lithium, or else that the atom of platinum presents 36.4 times as much surface as that of lithium; but the first supposition is inadmissible, since the atomic weight of platinum is 15.3 times as great as that of lithium (which would make the density 557 times as great). On the other hand, the second supposition leads to the strange result that the denser a body is, that is, the smaller its specific volume is, the larger is its atomic volume. This result is contradicted by the fact, experimentally determined by Bessel, that the weight of a body is always proportional to the mass of matter which it contains and has nothing to do with its dimensions. Finally, if this is not enough, the fact that each atom of a body exercises its gravitational attraction as if all the rest were away, proves that there is no such thing as a screen which can shield a body from the influence of this force. Whether we comprehend it or not, gravitation involves energy. M. Hirn was of the opinion that energy is a power distinct from matter, capable of putting two separate portions of matter in connection, and of drawing them from repose, or restoring them to it without the transfer of motion from previously moving matter. Today we should demur to this definition, for we recognize that matter is itself a form of energy, a view which brings us very near to Swedenborg's position.

Again, gravitational energy is not the only energy which gives motion without direct contact; indeed motion is never directly transferred from matter to matter. Take the case of similar elastic balls, moving with equal velocity in exactly opposite directions, and colliding. For an instant, however short it may be, there is absolute repose. The science of thermodynamics teaches us that at this instant a quantity of heat, exactly proportional to the momentum destroyed, is developed in the balls, accompanied by a change of figure and a tension which is at a maximum. The heat and elastic tension progressively disappear, while motion in opposite directions is generated. A non-elastic body, however, like lead, is permanently distorted, and its heat is dissipated in other ways, motion not reappearing after destruction by impact.

Now atomic vibration alone will not explain how the elastic tension originated. The energy which gives the elasticity is present in the body before its parts are disturbed. It is entirely independent of the size of the balls in the experiment just described. What has been said will apply equally well to an atom itself, as to a collection of atoms. "If we admit that an atom in motion gives its velocity to another by contact, it necessarily follows that the atom is capable of being distorted, and that it is provided interiorly with a power, capable of bringing it back to its initial form lost by the shock." It is noteworthy that, on this hypothesis, the atom can not be a geometrical point. It has a structure and a complexity still to be unraveled. M. Hirn maintains that there is always a dynamic power antecedent to every material motion, and that when the motion is destroyed, this power (heat, electric field, or what not) remains as something distinct from the motion of matter. It can not be said, however, that the power is distinct or separable from substance. There must be a form—substantial, or atmospheric—to receive the force, before there can be any power. We should say that the energy goes back into the aura from whence it came. Swedenborg taught us the supreme importance of energy in nature, but, unlike Hirn, he was not contented to refer the invisible operations of nature to a vaguely conceived, unformed entity. He insisted that there must be forms ready to receive the influx of power, that power and its instrument must be considered together, and by means of his searching doctrine of discrete degrees he removed the vagueness on which we are commenting and opened a new realm to the human intellect. We shall return to Swedenborg's doctrine of energy in the next section.

The existence of an energy more fundamental than electricity is implied by the admission by Clausius that his electric particles, whether at rest or in motion, act upon each other at a distance, and thus convey a dynamic influence extending around them to an indefinite distance; and if there are free electric particles, they must be in many ways similar to those of ordinary matter. Both are attended by dynamic fields extending to an indefinite distance.

A great number of bodies, both solid and liquid, are not only impenetrable, but are absolutely impermeable to matter, provided there is no chemical action between the two. The vacuum of our barometers is preserved indefinitely in spite of the surrounding atmosphere. Glass and mercury are then quite impermeable to air. This property is so characteristic that if we find a substance capable of freely traversing these bodies, we may safely affirm that this substance is other than matter. Such a substance is electricity, at least it can penetrate a solid metallic conductor. As static charge, it can act upon a suspended metallic needle, or as moving charge, it can impel a magnet, through the glass walls of a receiver. So can the gravitational attraction of matter, but the laws are different, and that which penetrates is not matter. The fallacy of the idea that electricity may be a vibratory movement of the metal which constitutes the conductor, is shown by the fact that a conductor retains a statical charge, after the current has been broken, that this charge acts at an indefinite distance through the surrounding space, whether this is filled with matter or empty, which no material vibration could do, and that, upon completing the circuit, the electric potential begins to fall and the current begins to pass, not at the pole of the battery where the vibration is supposed to originate, but at the extremity of the conductor which has been put to ground. Electricity is therefore neither a vibratory movement nor a circulation of material particles, according to Hirn.

This argument is conclusive against the hypothesis that electric current is a movement of gross matter, but it does not exclude a sort of ethereal motion, that is, the flow of a substance more subtle than gross matter; nor does it disprove the conception that the ether possesses structure, a conception which by its very nature implies that there is a medium back of the ether out of which ether is made. Whether the strains of static electricity are due to a vibration or to a special configuration of some entity, no reason can be adduced why they can not act through surrounding space by means of an atmosphere subtler than the ether. Many of the phenomena of electricity are analogous to those in a fluid. Thus the closing of an open circuit resembles the opening of a water faucet, where the head of water diminishes first at the outlet, not at the reservoir.

The letter of M. Jules Bourdin (*ante* page 196) is characterized by M. Hirn as a pretence of abolishing whatever we do not understand. To Bourdin and his school, says Hirn, the idea "that electricity can circulate in a solid conducting wire [or, as some would say, in the surrounding dielectric] as in a tube," appears improbable; "but this improbability disappears and a great truth remains if, discarding the terms matter, mass, and atoms, we supply the much more general term substance, and say that electricity constitutes a force [we should prefer to say, a form of energy existing in a distinct medium] that is, an element specifically distinct from matter, and capable (like gravitation for example) of putting the disjoined material points in that state of dynamic relation, which appears to us as an attraction or as a repulsion." Again we should wish to clarify Hirn's mode of expression, and to distinguish between electric or material particles and the dynamic field (either electric or gravitational) which exists in the surrounding aura and puts them in communication. The coexistence of different "elements" in the same body is illustrated by the complete permeation of matter everywhere by gravitation and by the partial permeation of certain bodies by radiation, which is proved by some of the surest facts of optics, to be not a vibration of the matter composing the body but of another "element."

The medium which fills inter-stellar space, is not the ancient ether of the physicists, endowed solely with elasticity, but one which is especially the seat of energy. We recognize at least three elements, distinct from matter, namely, gravitational energy, electrical energy, calorific energy. The first seems absolutely unchangeable as long as the distances and the quantities of matter, which it brings into dynamic relation, remain unchanged. The other two, on the contrary, increase or diminish at the same point of space, being capable of special movements of their own; but it is not correct to say that they are transferred to matter by a direct impulsion. It is possible that the distinction between these forms of energy is more apparent than real; but until the idea of energy becomes much less confused than it is at present, it is desirable to emphasize the differences.* The discovery that radiation, whether luminous or invisible, does not result from the motion of a material gas, filling interstellar space and the interstices of transparent bodies, but that it comes from a certain manifestation of electric energy, or else from the action of this energy upon a substance absolutely distinct from ponderable matter, a substance capable of manifesting itself as energy, is an immense step in advance.

Let us next inquire how sensible heat gives mechanical work. It is said that the molecules of a body approach each other and recede alternately, with a rapidity whose precise value determines the temperature of the body. Their approach, or their tendency to approach each other, evidently results from a force; but why, after approaching, do they separate again? Two replies are suggested. Either the molecules continue to approach until they come in contact, are deformed, stop, and then recoil in an opposite direction by virtue of an elastic repulsive force within the molecule, as Clerk Maxwell has deduced, or else their velocity diminishes before contact, ceases entirely, and is reproduced in the opposite direction, by virtue of a repulsive force emanating from the molecule. In the former case, the molecules must be perfect elastic spheres; in the latter, they may have any shape whatever and the elasticity resides in the surrounding medium; but in either case, we have finally to admit the existence of energy.

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* Elsewhere in this work I have characterized these as the energies of pulsatory, vortical, and translatory motion, but always with relation to the underlying aura.

In order to explain thermal phenomena by molecular motions, it is necessary, in the case of a gas far removed from its temperature of liquefaction, to suppose; first—that the atomic groups are quite independent and separate from each other by finite intervals; second—that they have a rectilinear and uniform movement of translation upon a path which is indefinitely great, relatively to their own dimensions; third—that the duration of their shock against other molecules is very small, relatively to the duration of their rectilinear motion. These conditions, first stated by Clausius, have been reaffirmed with slight modifications by Maxwell.

Many of the phenomena of gases are admirably explained by the kinetic theory; but, as M. Hirn says, thousands of facts may favor a theory and render it plausible, while a single contrary fact suffices to refute it. Hirn thought that he had shown that in adopting the kinetic theory, we are led to the following false conclusions:

First, that the resistance of a gas to the movement of a projectile is, at constant density, dependent upon the temperature. This, he says, is absolutely refuted by experience.

Second, that the laws of the flow of gases from one reservoir into another, where the pressure is less, are quite different from those which experience demonstrates. Thus, notably, the atmospheric air at a temperature of 0°C. and at any pressure whatever, ought to take the limiting velocity of 485 meters per second, when it escapes into a space where the rarefaction is complete. This is disproved by experience.

Third, that the velocity of sound in air or any other gas, ought to depend upon the pitch, which is absolutely false.

Fourth, that the height of the atmosphere ought to be limited to about 12,000 meters, which is much below the truth.

I will take up these objections to the kinetic theory of gases in their order. It is easy to dispose of the first objection by rearranging the form of the experiment. The form in which it is stated is badly chosen. A bullet has a relatively large mass, compared with the surface which it presents to the air. The conditions are not favorable for detecting a small secondary variation in the air resistance. If, however, we let the air be the moving body, and let it pass through a long tube, we have a small mass and a large frictional surface. Under these circumstances, the resistance to the flow of gas increases with the temperature, as the kinetic theory predicts.

The answer to the second objection is that the escaping gas can not attain the theoretical velocity of 485 meters per second at 0°C., because friction against the walls of the nozzle, and against its own particles adhering thereto, holds the flowing air back. That this is the true explanation is shown by the fact that when the gas is heated, the time of flow for the same difference of pressure is lengthened. The velocity is slower, because the hot gas is more viscous, and friction is greater. The velocity of air flowing into an exhausted receiver increases with larger difference of pressure until the difference is a little over half an atmosphere; bu for greater differences of pressure than this, the velocity remains constant, evidently because it has reached a limi determined by viscosity. M. Hirn has himself given us thi limiting velocity for a conical, converging orifice of 9° aper ture, and 0.4964 sq. cm. in section, giving a section of th vein of flow at the point of maximum contraction of 0.4887 sq. cm. At the temperature 15°.75 C., he obtained a velocity of 201.14 meters per second at all differences of pressure greater than about 40 cm. of mercury. The computation by which he deduces that the flow into a vacuum should be with infinite velocity, and that his 201 meters denotes a velocity of 4,266 meters for vacuum, is simply a blunder which the consideration of Newton's first law of motion ought to have prevented. The forces acting are not infinite, but are differential and strictly limited.

In a special communication to the Académie Royale de Belgique (Bulletins, 3me Série, Tome 11, No. 3, 1886), M. Hirn corrects the former statement of his third objection and explains that he meant that "an *intense* sound ought to be propagated more rapidly than a feeble sound," but the correction does not matter much. In either case, M. Hirn neglects the recoil of the particles, that is, the motion with reversed sign, which permits us to call sound a "vibration." In his memoir on "The Laws of Flow and of Shock in Gases" (*Recherches sur les Lois de l'Écoulement et du Choc des Gaz en Function de la Température,* page 179), he says: "The vibratory state, or even the ability to vibrate, presupposes a continuous solid union between all the parts of the body; a solidarity such that no part can be displaced to the least degree without the other's experiencing, sooner or later, if not a displacement, at least a change in their conditions of equilibrium. . . . In gases nothing of the sort exists."

In regard to this, it is quite true that there are no solid connections between the particles of a gas, but it does not follow that a gas is not susceptible to vibrations of certain kinds. In separate particles, there may be internal vibrations of several sorts; for example, there may be radial vibrations, or the alternation of expansive and contractile movements;

deformatory vibrations, as in the oscillation of a sphere between the oblate and the prolate spheroidal figure; or there may be angular oscillations, or librations, of the particles, and the libration may increase until it becomes a rotation with varying speed, if the components are unequal. Besides these, we must recognize a translational vibration, as in sound, with which that of heat may be compared. The sound-wave in air is the propagation of a series of condensations resulting from the crowding together of a multitude of particles which press upon one another through their translatory motions.

M. Hirn compares the movement of air particles to that of a row of ivory balls, suspended by strings, where if an end ball falls with a certain speed, the ball at the other end of the row rises with an equal velocity; but the comparison is not a good one. The balls are initially at rest. The air molecules are never at rest, and the velocity with which they transmit a disturbance is their own velocity (slightly modified), and not that of the disturbance. Moreover, the air molecules are not arranged in strings with free end members, though we may admit that the continual interlacing and exchange of their paths gives them a *virtual* contact by their alternating, translational, thermal motion. M. Hirn does not seem to have considered that the thermal energy is purely relative. It is that portion of the energy of general motion which, being given by alternate positive and negative values, is distinct from the energy of continuous mass-motion.

It is possible that there may be a slight variation in sound velocity, if the sound is very intense, since the thermal properties of the air may change under great stress. Such variation has been certainly detected in the first initiament of the sound-wave from the discharge of heavy guns. Professor Dayton C. Miller says: "For a 10-inch rifle, firing the service charge, the total displacement of the center [of the spherical sound-wave whch moves forward along the line of fire for a short interval of time] has been found to be about 72 feet, which value is attained in about 0.2 second after the discharge of the gun. . . . After the initial displacement . . . the normal velocity is maintained indefinitely." (Physical Review, February, 1921, page 256).

The fourth objection made by M. Hirn to the accepted theory of gases relates to the supposed height of the atmosphere. It is true that the pressure at a point in the free atmosphere, although equable in every horizontal direction, is not exactly identical upwards and downwards, since the weight of every molecule increases its velocity when descending, and diminishes it when ascending. A mass of air, transported from one altitude to another, is compressed or expanded according to the change of pressure produced by gravitation, and is thus either heated or cooled. But this is not the only way in which the temperature may be changed. The temperature, or molecular movement of the air at any height, depends on many factors, and largely on absorption of radiation. This in turn depends on the distribution (by air currents) of the chief absorbent—water vapor. The molecular motions in the upper air are continually being increased in this way.* A part of this heated air descends in anticyclones, and in summer gives hot waves, but to counterbalance this there is strong ascension of warm moist air in cyclones. Evidently, the distribution of heat in the atmosphere does not follow any simple law. Moreover, since Maxwell makes the maximum velocity of the molecules *seven times* the average velocity, Hirn's computation of the height of the atmosphere deduced from the mean velocity of air particles at 0°C., must be increased in at least this ratio, giving 84,000 meters as a minimum value, which is not so far below his own estimate of 100,000 meters. To this must be added a further extension of the atmosphere by small amounts of gases lighter than air which accumulate in these outer layers of temperature for which air becomes a solid.

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* Compare F. W. Very, "Atmospheric Radiation," page 123; also "The Radiant Properties of the Earth from the Standpoint of Atmospheric Thermodynamics," page 29.

Among the many interesting researches on the flow of gases which M. Hirn has executed, there is one in which a stream of air issuing from a conical nozzle, 0.5 sq. cm. in section, presses against the horizontal plate of a balance, and is counterpoised by a weight in the other pan (*loc. cit.*, page 75 *et seq.*). The air passes through a tube heated by a furnace, and has its temperature raised nearly 200° C. before delivery at the outlet. Comparisons were made between the shock of moving air against a plane surface of indefinite extent, when the air-jet was cold, and when it was hot. The pressures at the reservoir were the same in either case, but since a part of the elastic force of the hot air was given to it in the heater, a smaller weight of hot air was moved under the influence of the constant hydrostatic pressure. Since the path was otherwise equally free in both cases, the hot air must have been held back by greater friction at the orifice; and this is what we should expect from the kinetic theory, because, owing to the more rapid movements of the molecules among themselves in the hot air than in the cold, collisions are more frequent and greater interference with the flow of adjacent layers is produced by collisions of molecules interpenetrating from one layer into another.

The hot rarefied air issued from the nozzle with the greater linear velocity, and with a larger volumetric output, but the stream conveyed a smaller mass of air in the unit of time. The momentum, or product of the larger velocity by the smaller mass for the hot air, was sensibly the same as the momentum of the cold current. Nevertheless, the impact of the hot jet against the plate of the balance gave the smaller pressure. The meaning of this is that the velocity of the jet suffers further diminution after leaving the nozzle, through internal friction of its interpenetrating moving molecules, and that this retardation is greater for the hot and more viscous air. The kinetic theory is thus fully confirmed. Hirn, however, did not draw this deduction, and did not recognize the meaning of his experiment as regards the kinetic theory, because, in his mathematical analysis, he started from a wrong premise, as we shall see.

Before the flow begins, a certain number of molecules are passing through the aperture of the nozzle with a velocity, $+U$, and an equal number with the opposite velocity, $-U$. Starting the flow alters nothing in respect to this alternating thermal motion. The positive and negative values of U merely cancel out in either case, and another local velocity, which is not thermal, is superimposed. Failing to recognize this, and assuming that only positive values of U need to be considered, Hirn obtained (*loc. cit.*, page 102) the following expression for the pressure on the plate:

$$p = \frac{\delta\,(ms)}{g}\left\{2/3\,UV + V^2\right\}$$

where δ is the weight of unit volume of the air, ms is the minimum section of the contracted vein of flow, g is the acceleration of gravity, V, the velocity of flow, and $U =$ the molecular velocity due to heat. If both positive and negative values of U are included, the term containing U disappears, and we have the correct equation:

$$p = \frac{\delta\ (ms)\ V^2}{g}$$

which agrees with the results of experiment fairly well, although it could be improved by adding a term to express the retardation by friction.

Ratio of p (observed) to δv^2 (computed)

t	$\delta v^2/p$
21°.5 C.	1.23
21.5	1.23
22.2	1.24
159.0	1.24
175.0	1.25
196.0	1.28

All of the objections urged by M. Hirn against the kinetic theory of gases having been refuted, the theory emerges from the test stronger than ever; but while rejecting his critique of the kinetic theory, I fully agree with his contention that there are other forces in nature than those of moving matter, and that we have not reached the bottom of an explanation when we have reduced it, in a preliminary way, to a problem in mechanics. "We have no idea of the essence of motion, any more than of the essence of matter or that of any other element constituting the universe." All we know is that something more must be found in a moving body than in one at rest.

M. Hirn uses the following illustration: The existence of energy in nature without any connection with either matter or its motion, can be proved. When a projectile, such as a ball of lead, strikes a rigid obstacle, it becomes hot, and the quantity of heat developed is rigorously proportional to the kinetic energy destroyed. (Note that air particles are projected equally with leaden bullets, though, being elastic, they do not flatten out like balls of lead, but rebound.) But we can heat the leaden ball just as well by exposing it to the sun's rays, and here again, the temperature, or elevation of calorific intensity produced, is proportional to the radiant movement extinguished. The term "kinetic energy" as used in mechanics, is strictly applicable to radiation, since the radiant beam is possessed of mass and momentum; but its entire energy, mass and all, is transferred to an absorbing body. The case illustrated is now recognized as an example which requires the introduction of non-Newtonian mechanics.* This is something which is equivalent to kinetic energy in matter, is an ethereal energy, but includes the latent material energy which we call the mass of a body, which is never transferred in matter. Hirn, oblivious to the fact that the light-bearing ether has momentum, assumes that it is substance without mass and concludes that the fact that the movement of a substance without mass can, by its excitation or extinction, give rigorously the same results as the excitation or extinction of motion in a material mass, shows that "energy with whose action all idea of [material] movement is irreconcilable, can not increase or diminish in strength without simultaneously producing a numerically equivalent decrease or increase of movement in some medium, no matter wheher it be material or nonmaterial." This "relationship between the very essence of motion and that of energy . . . shows us that what we call kinetic energy, or mechanical work, consists of quantities which are not necessarily bound to the existence of ponderable matter."

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* See the paper by Professor Lewis, "A Revision of the Fundamental Laws of Matter and Energy," in the Technology Quarterly for June, 1908, and some comments of my own in the paper on "The Conservation of Mass and the Passing of Matter" in Science for October 8, 1909, noting that the "ether" then spoken of is the universal atmosphere, or what I now prefer to call the aura. Some slight emendations to this paper will be found in my article on Halley's comet in the Scientific American for February 5, 1916.

A great mathematician has said that from the most beautiful equation we draw out only what we have put into it; but, to be just, he should have added that we always put in a great many things which it would be impossible for the most penetrating mind to see directly. We put into the law of gravitation the fact of attraction in the inverse ratio of the square of the distances and proportional to the product of the masses, and the whole science of celestial mechanics comes forth. But what we can not draw from these equations, and that for the simple reason that we have not put it in, is a knowledge of the nature of the attraction. As a means of elimination, mathematical science stands forth in all its power, and by it we can know what heat and electricity *are not,* and thus arrive, little by little, at a clear idea, not of their essence, which is doubtless beyond our grasp, but of their office in the universe.

The moral of all this is, *be modest!* Cease trying to penetrate the *essence* of matter or of energy, and be contented to point out more clearly the difference between matter and that which conjoins material points, whether atoms or celestial spheres. As Mephistopheles sarcastically says in *Faust*: "The *whole* creation to God alone belongs by right."

In speaking of Hirn's paper as a powerful one, I am not overlooking some incongruities which it contains. I, for one, am not willing to give up the terms—"matter, mass, and atoms," although I am very willing to agree that there are underlying forms of substance to which those names are not applicable. By contrast, Swedenborg taught us that we can know nothing about function except through a knowledge of forms; and surely we know a *little* about hidden or internal form. Again, while it may be that what we have come to speak of as a "transformation of forces" is only an appearance, there must have been an original derivation of the different orders of substance (that is, forms of the one energy which is born from the spiritual influx), each from the other in the order of succession. The conclusion at which Hirn arrives, is humiliating to the pride of man. It is that, after all, we know next to nothing about either matter or energy; but as those who are spiritually poor, are nevertheless rich (Rev. II, 9), perhaps there is quite as much ground for hope in this seemingly desolating position, as there would be in one more satisfying to the natural craving of the human mind for dominion over the realms of philosophy.

Inasmuch as objections have been made to the kinetic theory of gases and its correlations by eminent scientists, it has seemed necessary to examine these subjects at some length. The result is that Swedenborg's hypothesis that the air particles (atoms) are expanded by heat until they touch, must be abandoned. But his supposition that the air particles (atoms) are spherical, is confirmed, though we now know that they are of several sorts. Also, in a certain sense, there is confirmation of his bullular conception of the structure of the particles, though the measurement of the sizes of atoms and electrons, together with an approximate estimate of the number of mass-giving electrons in the atom, and of their motion, proves that the outer shell of the atom is not composed of "finites" in close contact, as he supposed, but that the limiting, finiting, and resisting properties are given by the intense orbital revolutions of widely separated electrons and the resulting field of force; so that the atomic surface is an open network of electrons, with but little variation in its size. We shall return to the last point in what follows.

ENERGY

Although the problem of the nature of energy involve the eternal question of the relation of spirit to matter, which may be approached but never completely solved, still some progress has been made. We have learned that the aura is the great storehouse of energy. Its properties are in every way more complex, more wonderful than those of matter It is the substance out of which matter is formed.

The mathematical theory which expresses the movemen of material bodies is insufficient for the motions of the aura Maxwell had to invent new mathematical methods in hi treatise on "Electricity and Magnetism." It was Michae Faraday who first laid the foundations of modern electrica science by his experimental researches; and Faraday's "line of force" assumed a *medium* in which certain processe were going on. This medium is no other than Swedenborg' aura which is the indispensable connecting link giving unit to the physical forces.

Professor (now Sir) Oliver Lodge has described in hi "Modern Views of Electricity" various mechanical device whose movements help us to understand what goes on i the aura (called by him the "ether of space"); but it is no claimed that they are more than analogues invented to ai the mind in its attempt to follow a train of complex processes. Professor (now Sir) J. J. Thomson in his "Recen Researches in Electricity and Magnetism" employs a mor searching analysis, and he has given us in his working hypothesis of vortex-filaments in the universal atmosphere, physical principle which enables the mind to form a pictur of the processes and one which at least serves as a basis fo the mathematics, and probably more nearly approaches th reality than the mechanism of gear-wheels and slippin wheels employed by Lodge as an illustration. The aur must be regarded as everywhere threaded by vortex-filaments, running in all directions, but which may be transferred in particular directions at definite locations, constituting by their crowding an electric field of force. The coördinated movements of large numbers of vortex-filaments, arranged in a triply vorticose order, namely:—(1) the basal vortex-filaments of the free aura, (2) the circulation of an electric condensation-wave among these filaments around the axis of a magnet, and (3) the wave itself, considered as a magnetic vortex-filament, or tube of magnetic force—produce the associated magnetic field.

The most complete analysis of the problem of the aura, considered as the vehicle of electrical energy, is that of Mr. Oliver Heaviside; who, by the invention of an improved system of quarternions, has succeed in rendering the exceedingly complex processes amenable to treatment in concise and elegant mathematical expressions, though the original Hamiltonian analysis is easier to follow. The meaning of these formulas can only be grasped with difficulty by those possessing a complete education in the higher mathematics and the gift of a mathematical mind; but there can be no doubt that Heaviside has given us the most searching analysis invented hitherto, and an instrument of great power for unraveling the secrets of the universal magnetic medium. This leads to Swedenborg's doctrine of energy and the function which it performs in the production of matter.

SWEDENBORG'S DOCTRINE OF ENERGY

Swedenborg ascribed the origin of nature to Divine Influx (as we have seen in Chapter I),—first into a world of spirit in which spiritual atmospheres in three degrees are produced from the Sun of Heaven. These spiritual substances are alive. Thence from the spiritual world there is a descent by a discrete degree into the natural, producing there other suns and atmospheres which have no life in themselves but which serve as vessels for the reception of Influx. The only *real* substance which has Life in Itself is the Divine Love. Its ultimate in nature is *energy,* of which we can know nothing except from its analogy to the human will which is love, or desire to accomplish uses.

The natural universe and its recipient forms, from least to greatest, have arisen through a perpetual creative inflowing at innumerable centers of creative energy. These centers have been formed out of the superspace of the spiritual world, where each center comprises innumerable things. But as discreted in nature, all of these complexities unite in a single limit—the first natural point—the *starting* point, as Mr. Odhner has well said. Chapter II. of the first part of the *Principia* treats voluminously of this "first natural point." Sweeping aside most of this metaphysical discussion, we need only attend to a few of the details of the argument.

The first natural points are centers of energy and of motion. "Geometry can neither express the effort toward this motion, nor describe its figure, except by similitude." (New English edition of the *Principia,* I., page 71). The energy on the natural side is "not yet anything, but only about to become something; and in this state it lies as it were in embryo till matured; that is, it can not as yet be analyzed by finite terms or limits, which nevertheless successively arise from this ovum. Since therefore this point can receive no adequate geometrical demonstration, we must have recourse to the principles and axioms of rational philosophy, and instead of the point substitute an entity, and so proceed to its investigation by the attributes proper to such entity." (*Ibid.,* pages 71-72).

Since "complete motion, or that which is internal, tends to a figure most perfectly and purely mechanical, that is, to the spiral, we hence obtain an idea of the internal state of the point; by which internal state we perceive the quality of the energy (*conatus*) as it presses forward into external motion. The real determination and direction of active or local motion is solely owing to the figure by which this energy exists. It was before observed, that the figure is perpetually spiral, proceeding from the center to the periphery and reciprocally from the periphery to the center; by and according to which form it is inclined to direct every effort, and, as it were, to aspire to active and local motion. For if there be [a potential] energy tending to motion, and if a similar quality exists in energy as in motion, there will exist by similitude, figure and space. For example, if there is an energy tending directly from one extremity to the other, a rectilinear motion will ensue in that direction; but if the energy, by the form which it assumes, revolves round some center, in this case a circular motion will be the result. But not only is motion determined into form, it is also directed by energy; and thus whatsoever does or can exist in motion, is previously to be found in energy." (*Ibid.*, pages 72-73.) I have preferred to use "energy" as a translation of *conatus* in most cases, instead of "effort," because it seems to me that this word in its modern sense precisely expresses Swedenborg's meaning.

The final conclusion is that the resulting initial form is a *perpetual* spiral, which is elsewhere defined as a vortex, or elementary particle, and is described in detail.

"In the point, or in the energy of the point, lies concealed the whole power, both active and passive, of mechanically producing in just order and in regular succession, all finites whatever, or the world at large, both with respect to its smaller and simpler parts and its greater and composite ones." (*Ibid.*, page 74.)

As the influx of the soul into the developing embryo forms the structures of the brain which later are used to carry on the activities of the life,—storing up the physical basis of memory in the very form and structure of the brain induced through use—just so the inner energy which is the origin of matter, first forms the structures of the elementary particles, and then fills them with activity.

The first elementary particles are in perpetual, inwardly derived motion which can be compounded, but not destroyed. Thus the aura, or first atmosphere of nature, is both a substance and a force; for its entrance into the compounded forms of electrons and ether particles is a driving force imparting to them its own energy under new forms.

Veiled over and farther limited in atomic and molecular structures, the inner energy imparts to them their thermal motion and energy, while still preserving for their inmost structure its own inviolate matter-making activities.

Swedenborg compares this inmost untransformable energy of constitution to "heat" and speaks of heat as existing in three degrees, where evidently he means by the two higher degrees,—the inner energies of the aura and ether, comparing them with the thermal energy of the air, or what we should now speak of as that of atomic and molecular motions within gross matter.

Ordinary heat, such as exists in the air, or in solid bodies, is brought into action, he says, "according to volume," or "throughout a volume" (*volumatim actae*). This is entirely in agreement with our present conceptions. Heat, except where its distribution in matter is changing, is independent of time, and is sufficiently specified as a definite amount of mechanical energy *per unit of volume*. The heat is confined within the boundaries of a volume; and in free bodies, such as sun, planets, or meteorites in free space, or in a body completely surrounded by a vacuum, the heat can not escape except by being first converted into radiant energy *at a surface*. The C. G. S. unit of radiation represents "a unit quantity of heat, namely one gram-water-degree-Centigrade heat-unit, lost *as radiation* per square centimeter of surface per second of time" at the surface of a heated body, and therefore is to be stated as a function of area and time as well as of energy. In the Astrophysical Journal for December, 1898, (Volume VIII, page 271; see also Meteorologische Zeitschrift, October, 1901, page 472) I suggested the name of "radim" for this unit of radiation, and urged its use in order to discriminate betweet thermal and radiant energy; but the suggestion has not been adopted, and to this day the indiscriminate use of the word "heat" to cover both thermal and radiant energy, so that, which of the two sorts of "heat" is meant has to be determined by the context, continues to produce confusion in scientific literature, and is a prolific source of error. Tyndall is largely to blame for this vicious practice since, although he made valuable contributions to the science of radiation and spoke much of "radiant heat," meaning by this expression *radiation*, where, though the name was objectionable, there was no danger of any misunderstanding, he often dropped the adjective "radiant" and expected his readers to supply the word. Preston in his "Theory of Heat" seldom introduced the adjective at all. Langley's writings are not free from the same fault; and as these early treatises are still regarded as classics, they have set a vicious fashion. Chwolson comments most energetically against this practice in the second volume of his *Traité de Physique*, Chapter I, Article 12, on *Terminologie* (pages 28-29). Since the translational energy of a mass in motion can be converted into thermal energy when the motion is changed into indiscriminate molecular motion, either through friction, or when the mass-motion is stopped by impact, it is permissible to evaluate the heat in terms of equivalent mechanical energy. Similarly, the value of a quantity of radiation may be stated in equivalent units of thermal energy transformed at unit surface in unit time. But the radiation should never be called "heat."

Chwolson (*Op. cit.*) says: "We can no longer preserve the old terminology which supposes, on the one hand, an essential difference between light and radiant heat, and, on the other hand, a complete identity between heat in the ordinary sense of the word, and the form of energy which propagates itself by radiation in the ether. The significance of the old terms *radiant heat, calorific rays,* for example, implies the belief in this identity. Consequently, *we shall not employ them,* for they rest on inexact ideas and may lead to misunderstanding."

The Rev. John Worcester in his "Correspondences of the Bible" (Part II, page 297) quotes Swedenborg's statement: "The ethers and airs made active in masses produce heat, but modified in particulars they produce light." Here Swedenborg uses the term "heat" in its strictly scientific sense to denote the inherent thermal activity in large "masses" or volumes of matter (we may presume that the "ethers" mentioned are those which he supposes to be bound up with matter, though we do not even now know whether this bound ether shares in the thermal activities of the matter associated with it). But light is ascribed to passing modifications in minute particles (even as we now conceive that the light-quanta are emitted by excessively small vibrating electrons). Mr. Worcester, however, misled by the misuse of terms which has been referred to, imagines that by "heat"

Swedenborg means the longer-waved ether-motions of the infra-red spectrum and says: "The heat motions affect larger masses of the ether, rolling it, as it were, in larger [longer?] waves, fewer of which are contained in a given space, or will strike the body in a given time." This completely misrepresents the meaning of the passage, and if allowed would destroy correspondence.

In *Arcana Coelestia,* n. 34, we read: "The life of faith without love is circumstanced as is the light of the sun without the heat; as in winter . . . But faith from love is circumstanced as is the light of the sun in the time of spring, when all things grow and flourish." Of this I said in the New-Church Review (Volume VII, p. 356, 1900) "If heat were merely ethereal vibration of long wave-length, it could not be said that in winter the light of the sun is present without heat, since the infra-red rays are relatively more powerful in sunlight in winter than in summer, because of the comparative absence of atmospheric moisture in winter, these rays being especially obstructed by aqueous vapor. The heat which is present in summer, but absent in winter, is atmospheric heat, derived from absorption of the sun's rays by aqueous components."

The need of a true science to serve as a basis for spiritual truth is well illustrated in this instance. The truths of faith, in order to be efficacious, must enter into the life, or be "absorbed," even as the sun's rays are absorbed by the atmosphere in summer, producing atmospheric warmth. Though his statements in the theological works are true, Swedenborg was not quite clear on this point in the earlier scientific treatises. He thought that there might be such a thing as "cold light." In a certain sense this is true. The radiation of the firefly consists in a comparatively narrow band in the visible spectrum where, if it were produced by a flame, its presence would imply intense combustion with a temperature so high as to destroy life, and an accompanying very much larger amount of infra-red radiation; whereas in the firefly infra-red radiation is almost lacking and the visible light is given off at body temperature. But within its very limited range, the light emitted by the firefly is heat-producing, like any other light or radiation, whether visible or invisible, when received upon a suitable absorbing surface; and in this way I was able to measure its amount by means of a very delicate bolometer which recorded the heat produced in a thin strip of blackened platinum illuminated by the light of the firefly, and which also showed a very much smaller heat in corresponding stretches of the infra-red spectrum from the insect.

But in the *Principia,* in speculating as to the cause of his "cold light" from phosphorescent bodies, our author assumes that it is due to an absence of internal revolution of the first elementary particles enclosed in the ether particles whereas, as we have just seen, the phosphorescent light equally with light from an incandescent body or from flame is able to heat an absorbent thermoscope; and the heat produced is exactly proportional to the intensity of the rays no matter what their source may be. There is nothing the matter with the ether. It responds with precision to all the various vibrations and pulsations of the electrons. Moreover, it appears probable that the light-bearing ether-particles, when flung off from the vibrating electrons, duplicate not only the form and frequency of the vibration, but also the dimensions of the originating electron.

As to the bound ether which accompanies material bodies and penetrates their smallest pores, physicists speak of i as more or less "dense," but without knowing precisely wherein its density consists. The varying refracting prop erties of matter rest upon this "density" of the bound ether, and it may very well be that here the density is determined by a varying condensation of the ether particles depending upon internal motion. The hypothesis is at any rate worth considering and the mechanism described is ingenious. Swedenborg assumes that the interior of an ether particle is filled with active first elementary particles whose motion it distended, and is enclosed by a spherical shell of finiting particles already condensed as much as they can be, and arranged with their attracting poles in contact, forming a spiral line whose turns are practically a series of circles, since the finites are very numerous. When the actives are in their greatest motion, they are arranged in radial lines and revolve rapidly, giving an outward pressure which distends the outer shell to its utmost. If the interior motion diminishes, contraction ensues, and since the finites of the shell have nowhere else to go some of them betake themselves within, eventually duplicating the bounding layer. With still further contraction, more of the finites are displaced from the surface and form smaller interior spheres, each enclosing a volume of actives like those which surround them, until the whole cavity is filled with little spheres and further shrinking is impossible. The internal active motion will then have nearly ceased.

We do not know enough about the ether to either affirm or deny these statements; but the case is different in respect to the air particles. These, according to Swedenborg, are entirely similar to ether particles, except as to size.

Since fourth finites enter into the surface of the ether, and fifth finites into the surface of the air particle; and the fifth are of a similar nature to the fourth, they are capable of passing through the surface in a similar manner. Moreover, these particles are similar in regard to their internal space; for the first elementaries fill and constitute the space of the ether particle, and the first and second elementaries that of the air particle; and because first and second elementaries are similar and differ only in dimension, it follows that they produce similar effects upon the surface; they differ therefore only in dimension, and consequently in degrees and momenta. It also follows that the second elementaries occupy the internal space of the air particle, because they are larger and can operate upon fifth finites or those of a greater dimension, and form them into surfaces; but the first elementaries can not do this except in relation to the fourth finite. (Ibid., Vol. II, page 227.)

The air particle thus formed, and equilibrated is highly elastic, and is properly called elementary. It owes its elasticity, however, to the enclosed first and second elementaries, in which the primitive elasticity is latent. It may thus be expanded, compressed, and may yield, simply by aid of the enclosed elementaries. (Ibid., page 229.)

And in the section on Fire, we are told that:

The ether and air particles, when in their central motion, act also upon structural connections similar to their own, and consequently produce a kind of heat or fire. Heat is thus a most intense central motion of the parts of air or ether. (Ibid., page 247.)

These statements can now be compared with present-day science which informs us that, while a part of the action of heat on air is to increase the rotary motion of atoms and molecules (inner energy), a further effect is to exalt their speed of translation and thereby produce the work of expansion. The rotary changes bear so small a ratio to the constitutional internal rotations and revolutions of the electrons within the atoms that any thermal expansion thus induced must be relatively very minute and the expansion of the air by heat can not be attributed to any change of volume in the individual air particle, but is due to the increase of its local motion.*

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* A partial exception to this rule exists in the carbon atom.

Moreover, we have no certain evidence that heat affects the volume of an ether particle or its local motion. (There is a slight change of refraction with temperature.) We must therefore reject a large part of the details of the theory of heat as given in the *Principia,* retaining only the general facts, that heat is due to an increase of internal motion, that both air particles (atoms) and ether particles are spherical, and that the air particle is much larger than the ether particle.

It is also true, in confirmation of Swedenborg's conception of an elementary particle, that an atom consists of some thousands of electrons in rapid revolution, which give to the atom its mass, and it would be permissible to call the energy of this central motion a higher degree of "heat," as he does.

Quite likely the electron is in turn produced by the internal revolution of thousands, or possibly millions, of aurions, with an internal energy which constitutes "heat" of a still higher degree. But the vortical form of the atom does not seem to be a precise repetition of that of the electron, as imagined in Swedenborg's succession of elementaries; and the series ends with the atom, since the next larger particle, the molecule, is neither vortical, nor spherical, and it is built up not of thousands of revolving atoms, but of comparatively few atoms (from one to, at most, something over a hundred in the most complex organic molecules). These atoms are arranged in relatively fixed patterns in free molecules with no constituent atomic revolutions. Possibly the atoms may oscillate or vibrate a little about their mean positions (they certainly do so during incandescence); but, in general, whatever rotation the molecule may have is communicated to it by some external shock and affects it as a whole fortuitously and without altering the internal relations of the atoms much.

As has been shown above (Chapter II, page 40, *et seq.*) electricity, or its first unit, the electron, may be identified with the first elementary particle of the *Principia*, having the form of a vortex-ring. The ether-particle is assigned by Swedenborg to a position two removes farther on in the series, which can not be admitted, since the two are closely associated, so much so that Professor W. L. Bragg at first thought that "an electron of given energy may be converted into a light-quantum of equal energy and *vice versa*"—a quasi-identity now abandoned though the similarity in size may be granted. Yet although Swedenborg did not know that the elementary particle which he had imagined had anything to do with electricity, and the thing could not have been foreseen until the discovery of the electron and the investigation of its properties, nevertheless, he associates ether (or light) with electricity. "The ether is urged into a whirling motion at a distance from its body, and this causes light and to a certain degree electricity." (*Ibid.*, page 221.) We can not consider this as more than a guess, but it happens to be extraordinarily near to Bragg's. Modifying this happy guess to conform with fact, we can put the ether where it belongs, finding that it is not a "third element" with particles of an order greater than the atomic ("second elementary"), but that it is closely associated with the first or electric elementary both as to origin and magnitude. The adoption of this point of view clears up the whole subject and proves that Swedenborg builded better than he knew, and that his ideas need only some slight modification and rearrangement to bring them into agreement with facts.

Part III, Chapter IX, n. 1 of the *Principia* begins thus:

"A particle of water is similar to a compressed particle of air." This statement, made long before it was known that air could be compressed to a liquid resembling water in appearance, would be quite notable, were it not for the abandonment of the suggestion in the following chapter where, in treating of water vapor, Swedenborg, prepossessed with his conception of an indefinitely extended succession of precisely similar "elements," instead of sticking to his previous suggestion and likening the expanded water-particle to a particle of air, adopts the wholly erroneous idea that aqueous vapor is a "fifth element," formed on the usual model and having particles much larger than those of the air. We have seen that the conception that an air-particle is a "fourth element," much larger than the elementary atom and formed on the same plan as the ether particle, cannot be admitted. Still less can we espouse the theory of aqueous vapor which says that "particles of vapor differ from bubbles of water in this respect, that interiorly the former contain only ether, while the bubbles contain both ether and air." (*Ibid.*, page 266); but the air particle is filled with "first and second elementaries." (*Ibid.*, page 227). We can now be assured that aqueous vapor is a gas, like air, and that its particles are not expanded by being puffed out with ether; but that the evaporation and expansion of water into steam is produced solely by the increase of heat.

The formula of heat in gases requires the introduction of a small term representing the volume of the gaseous particles; but this term is relatively insignificant, and the increase of volume by heat is due to the forcing apart of the particles and the lengthening of their free paths as a consequence of increased translatory motion, more vigorous impacts, and greater resulting pressure by the bombardin particles, if the gas is enclosed within walls.

Swedenborg's point of view may be illustrated by th following quotation:

> At present we shall follow the successive steps of the serie and show how a particle of water is perfectly similar to a pa ticle of air, or indeed is the same as a particle of air highl compressed. And because in this particle there is nothing elasti and yielding, for the enclosed elementaries are consumed i compounding the globule,—which in consequence of being i teriorly deprived of its elastic elementary volume can not b farther expanded, much less compressed, or be made to yiel or to flow among the neighboring particles in virtue of its ow proper mobility and so to remain, in every state of motion, sin ilarly and perpetually fluid,—and the consequence is, that th globule or particle can not be called elementary. (Ibid., page 256

Evidently, having adopted the hypothesis that heat is th energy of the central motion of the particles, our autho concluded that it would make no difference whether th central filling was composed of "first and second elemen aries," or of "ether," after this filling had been all squeeze out. The fallacy involved in this idea will serve to remin us that chemistry had not yet been born, and that such vagu speculation as this was abolished when Priestley discovere oxygen, when Lavoisier demonstrated the existence c chemical elements, and when the conceptions originall broached by Lomonossoff were affirmed anew and verifie

Considering that heat is only another name for interi energy, we may admit the propriety of calling the inn energy of aurions, electrions, and atoms so many "degree of heat. But, as Clausius pointed out, electricity can n be converted into heat nor heat into electricity; and v may add that the inner constitutional energy of the aurio and electrons is not transformed into radiant emanatio but the latter, which in its visible form we call light, is wholly a prerogative of the ether. Swedenborg's declaration that there are three different kinds of light, as well as of heat, requires interpretation. One interpretation would find fulfilment in the fact (unknown in his day) that there are continuous spectra obtained from incandescent solids, band spectra from vibrating atoms in gaseous molecules, and line spectra originating in the perturbations of the electrons within the atoms.

THE CONSTITUTION OF MATTER

Let us now come back to the consideration of natural substance, defining this term as the space-content of the universe, and thus including substances which are devoid of gravity, and to which a wall of ponderable matter is (at least under certain conditions) no obstacle. After Hirn's masterly exposition, I think we shall be ready to admit not only the possibility, but the probability of such forms of natural substance, especially since we are thereby led to some very striking analogies between the degrees of matter and of spirit.

To begin with the aura: The aura, called by Maxwell the "æther," is defined by him as "a material substance of a more subtle kind than visible bodies, supposed to exist in those parts of space which are apparently empty." Maxwell has elucidated the subject in the following admirable way:

> The evidence for the existence of the luminiferous æther [here assumed to coincide with the universal medium, a view which must now be modified] has accumulated, as additional phenomena of light and other radiations, have been discovered; and the properties of this medium, as deduced from the phenomena of light, have been found to be precisely those required to explain electromagnetic phenomena. . . . That light is not itself a substance, may be proved from the phenomenon of inter-

ference. A beam of light from a single source, is divided by certain optical methods into two parts, and these, after traveling by different paths, are made to reunite and fall upon a screen. If either half of the beam is stopped, the other half falls on the screen, and illuminates it, but if both are allowed to pass, the screen in certain places becomes dark, and this shows that the two portions of light have destroyed each other. Now we can not suppose that two bodies when put together, can annihilate each other; therefore light can not be a substance. What we have proved is, that one portion of light can be the exact opposite of another portion, just as + a is the exact opposite of — a, whatever a may be. Among physical quantities we find some which are capable of having their signs reversed, and others which are not. Thus a displacement in one direction is the exact opposite of an equal displacement in the opposite direction. Such quantities are the measures, not of substances, but always of processes taking place in a substance. We therefore conclude that light is not a substance but a process going on in a substance, the process going on in the first portion of light being always the exact opposite of the process going on in the other at the same instant, so that when the two portions are combined, no process goes on at all. To determine the nature of the process in which the radiation of light consists, we alter the length of the path of one or both of the two portions of the beam, and we find that the light is extinguished when the difference of the lengths of the paths is an odd multiple of a certain small distance, called a half wave-length. In all other cases, there is more or less light; and when the paths are equal, or when their difference is a multiple of a whole wave-length, the screen appears four times as bright as when one portion of the beam falls on it.

The phenomena of polarization of light prove that the displacement of the medium must be at right angles to the path of the ray. "Whatever the 'æther' may be, it is capable of transmitting energy," which "exists for a certain time in the medium." It must be distinct from gross matter, for air can not transmit a transverse vibration, the amplitude being reduced to less than 1/500 part, in a single wavelength. The 'æther,' therefore, can not be molecular like a gas. [This conclusion does not follow if the ether consists of free oscillating particles, generating alternating currents in an aura which is itself composed of juxtaposed particles.]

"A medium, however, though homogeneous and continuous as regards its density, may be rendered heterogeneous by its motion, as in Sir Wm. Thomson's hypothesis of vortex-atoms in a perfect liquid. The 'æther,' if it is the medium of electromagnetic phenomena, is probably molecular, at least in this sense." The dual properties of the "æther" are best explained by the assumption of polarity which implies structure. We may conclude then, that what Maxwell called the "æther" is composed of parts, which therefore have form.

We have already seen that the air must be composed of parts which are widely separated, but the perfect elasticity of the supposed universal medium requires that, if composed of particles, these particles must be expanded until juxtaposition is effected, so that the medium behaves in some respects like a solid. This conclusion at which Maxwell arrives is wholly in accordance with Swedenborg's idea of the aura, but not with his ether. A suggestion by S. Tolver Preston, that the particles of the ether which convey light may be so widely separated that they scarcely ever interfere, but travel in all directions with the velocity of light, conveying some vector property, such as rotation or oscillation about an axis, mentioned by Maxwell, [though the idea, here attributed to Preston, is neither more nor less than Swedenborg's theory of light] may be regarded as an attempt to fuse the Newtonian corpuscular theory and the undulatory theory of light. In so far as the velocity of light is attributed to an inherent velocity of the ether-particles, a truth is no doubt expressed; but this inherent velocity is conceivably that of some special mode of vibration which is constitutional to the universal medium, rather than that of the translatory particle, though incited by the later. At least we may say that the supposition of such wide separation in the particles of the universal medium is untenable, since while, under ordinary circumstances, any number of luminous beams may intersect at a given point without interfering, under other circumstances, the meeting of rays is attended by a most remarkable interference which is incompatible with any such molecular independence as that supposed. The objection is valid in respect to the aura, but not in regard to the ether-particles formed out of the aura, for these do not constitute the sole medium or entity involved in the propagation of light, which interfere by their aural currents.

The computation by W. Thomson (Lord Kelvin) of the "density" of his "æther," still using this term in Maxwell's sense, which is given in the *Transactions of the Royal Society of Edinburgh* for 1854, in view of the certainty that this substance is imponderable, would, by some, be set down as a bad guess; but even premises which are only partly true, may yield valuable conclusions, and serve the purpose of a temporary scaffolding in the erection of the final building. His method is ingenious, although necessarily employing assumptions. Maxwell, in repeating the computation with a slight variation, used too small a value for the solar constant, but this deviation from more reliable recent data is nearly balanced by a numerical mistake in his work, so that after substituting Langley's in place of Pouillet's value of the solar constant, very nearly the same result is obtained, namely, "density of the æther" = $9.17 \times (10)^{-19}$, water being unity.

The mechanical conception of the universal medium has been carried even farther than this by Prof. De Volson Wood,* who, assuming that the medium continues everywhere through space and is simultaneously subject to the laws of gases, and possessed of the ability to transmit from the sun to the earth, a definite amount of energy with the speed of light, undertook to deduce the density, specific heat, elasticity, etc., of the medium, and even attempted to calculate the size of its component particles, and their number per unit of volume. The method had been partly anticipated many years before by Sir John Herschel. It is obvious from the start that the data are inadequate to the full attainment of so venturesome an undertaking, and Wood made some utterly unwarrantable assumptions and also several mistakes, some of which were pointed out by Chase, yet enough can be saved to furnish an analogue.

It must be observed at the outset that the simple mathematical expressions which Professor Wood used are inapplicable to a body which assumes an allotropic form or changes its state, and are only to be used for a gaseous body. If, therefore, his "æther" be not such a body, we may expect the application of these principles to yield some very curious answers to our questioning, which in fact, it does; but I am far from asserting that these answers are worthless or without meaning. One of the first results to which Professor Wood was led, is that unlike the aerial atmosphere, the "æther" is not appreciably compressed by its own weight, but remains of uniform density, a conclusion which would harmonize better with the hypothesis of an imponderable substance; and if his "æther" is the same as our aura, this was to be expected.

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* "The Luminiferous Æther." London, Edinburgh and Dublin Philosophical Magazine, (5) Vol. XX, pages 389-417, Nov. 1885.

In this paper, Wood illustrated the intense cold of the "æther" by the case of a meteorite which, in spite of having been heated to fusion at the surface, was intensely cold within immediately after its fall, but concluded that the space-filling medium can not be absolutely cold, since otherwise, on the kinetic theory, it would not be elastic.* While its temperature or sensible heat (granting the gaseous analogy) is thus at any rate very low, its specific heat or capacity for receiving heat and storing it away interiorly, is something enormous, approximately five millions of millions (specific heat of water being unity).

If the sun were composed of substances having such a specific heat as that here attributed to the substance of the universal atmosphere, it could maintain its present radiation for more than two millions of millions of years without any replenishing, and without cooling more than 1° Centigrade. Admitting that the universal magnetic aura absorbs a part of the stellar rays which traverse it, in spite of its enormous capacity for storing away heat, in the course of ages its temperature must slowly increase, especially in regions of densely clustering suns, unless the energy is stored in some other than the thermal state. This, as we shall see, appears to be the more probable hypothesis.

Since in different gases, the masses of the molecules are inversely as their specific heats, we may (assuming the "æther" to be molecular, as well as subject to the laws of gases) calculate the "mass" of an "æther" molecule. I have preferred to repeat the computation with data given by Clausius, and using Maxwell's value of the "density," that given by Wood being obviously incorrect even from the mechanical standpoint.

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* The medium must have energy which may be called "heat" of a new sort, but not of a kind/which can be thermometrically determined.

The operation gives:

"mass" of an "æthereal" molecule $= \frac{1}{6 \times 10^{35}}$ gram

number of "æthereal" molecules in 1 c.c. $= 5.5 \times 10^{17}$. The number of molecules in 1 c.c. of air at ordinary pressure, according to Clausius, is 3.7×10^{19}. A curious consequence is, that the "kinetic energy" of a molecule of this hypothetical substance would be nearly the same as that of a molecule of air, (Wood, *Op. cit.*, page 416) while its "mass" would be relatively infinitesimal. Suppose, then, that we go a step farther than the mechanical theorist has gone, and that we admit these suggestive analogies with just enough modification to make the suppositions applicable to the universal atmosphere. We may then say that the aura is composed of juxtaposed particles which have no mass whatever. We believe that they are as much smaller than the etherions as the latter are smaller than the atoms; and even if of the same size as atoms, the aurions would be far more numerous in unit volume, since the gaseous atoms are far apart. From the extraordinary internal elasticity of the aurions and the rapidity with which they transmit changes of pressure or configuration to great distances, they lend themselves to every possible deformation with such facility and with so little interference that *an almost infinite diversity of fields of force may simultaneously interpenetrate in the medium.* We admit then—

First: That aurions transmit longitudinal gravitational pulsatory waves which are remotely analogous to sound waves in air, though the resilience is from within the particles and not from longitudinal extensive motions and rebounds.

Second: That the great capacity of the aura for storing up energy, together with a rapidity of motion exceeding that of the ether, are distinctive.

Third: The aura, though a recipient of the energy which makes heat in matter, after this has been converted into radiation, absorbs the energy from heated bodies by a process which is peculiar to itself. It transmits but does not retain the energy appreciably except by a slow process enduring for ages. It acts by some internal mechanism which does not manifest thermal activity outwardly. It is therefore isometric throughout space, and is incapable of those variations of temperature, elastic pressure, and density, which the aerial atmosphere experiences. That is, like Wood's "æther," this analogue of air is extraordinarily diverse from air.

Fourth: Considering the special entity concerned in refraction, though this does not appear to be the same as the universal atmosphere, we may say of this ether, properly so called, that it surrounds every atom, constituting its individual atomic atmosphere which retards the velocity of luminous propagation in transparent media, because here the ether is bound to the atoms, shares their movement, and thereby suffers an infringement of its own freedom of motion. Similarly, a definite shell of bound ether is attached to the earth and shares its motion. Consequently, a ray of light from a star which enters the shell at the point *a*, but which moves independently of the shell, does not reach the observer at *b* until the particle of bound ether at *a* has

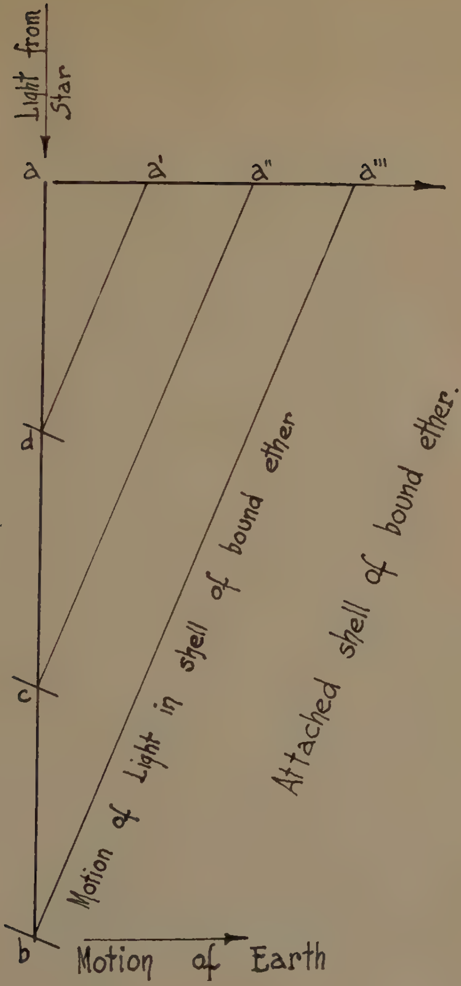
Light from Star
a
a'
a''
a'''
d
c
b
Motion of Light in shell of bound ether
Attached shell of bound ether.
Motion of Earth

FIGURE 4.

been carried to *a'''* by the orbital motion of the Earth.* The observer refers the direction of the light to that of the continuous line of ether particles, *a''' b*, concerned in retarding the luminous motion and along which the ray has finally traveled from *a* to *b*, retarded by the bound ether but otherwise independent of it. At the point *b* the ray enters the objective of the telescope. Its further retarding in passing through the telescope is negligible since the distance is relatively minute. This is certain, because Airy found that the aberration of light was the same no matter whether his telescope held air or water. Hence to see the star centrally in a telescope, the optical axis of the instrument must be inclined until it points in the direction of *ba'''*, making the angle *aba'''* with the true direction of the star, that is, with the actual path, *a b*, which the light would follow in the free aura. This is the angle of aberration, discovered by Bradley, hitherto explained on the supposition that the light-bearing ether is not bound, but yet is a continuous medium. Lord Kelvin alluded to the supposed difficulty of explaining the aberration after the discovery of bound ether by Michelson and Morley, as a cloud hanging over the undulatory theory of light; but in view of the simple explanation which Swedenborg's theory supplies, the cloud seems to be a thin one. At intermediate intervals, the line of bound ether-particles which has been active in retarding the light, and which marks its path relatively to the moving earth has the successive positions—$a'd$, $a''c$, $a'''b$—but as the angles at d, c, and b are all equal, and the lines are all fixed in respect to the bound ether which concerns refraction, but not aberration, we have no means of learning the real thickness of the shell of bound ether.

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* The appearance is as if the luminous motion is transferred to a particular row of bound ether-particles, but probably the latter do not take up the motion, but simply act as a drag on the original particles. The axis of the telescope must be placed normal to the parallel wave-fronts at d, c, and b, as explained by Professor W. H. Pickering in Popular Astronomy, Vol. XXX, No. 6, June-July, 1922, where it is suggested that a slight discrepancy between the computed value of the aberration (A = 20.″471) and the observed value (A = 20.″52) may be due to lack of sphericity or to eccentricity in the shell of bound ether.

Fifth: The last and most important distinction is that the universal aura, if its particles are everywhere in contact and rotating, has a dual constitution, requiring that, if composed of particles, these particles must be of two aspects having opposite motions, and existing in precisely equal numbers, so that there is complete neutralization and apparent inertness of the medium, in spite of its being the seat of vast energy. The case resembles that of a pair of equal wheels, excentrically weighted, lying in a vertical plane, and geared together. Any displacement of either wheel involves an opposite rotation of like amount in the other, and subsequent reciprocal oscillations about a mean position. If there is any lost motion it can only be recognized in operations on a vast scale, and the structure retains a complicated set of images of the processes experienced by it. This illustration is more than an analogy, since, if the aura is composed of rotating particles everywhere in contact, it is a mechanical necessity that the rotations shall be alternately right-handed and left-handed, and also that particles of like rotation shall be arranged in linear series, having contact preferably at the poles, as asserted by Swedenborg. This produces a filamentary structure of the aura in addition to, and because of the molecular one. There is much evidence that the vortex-filament is a special prerogative of the aura, and that Faraday's lines of electric force are also aural columnar vortices, though of a more complex type.

There must be some property in the aura analogous to inertia in order that its own rotational energy may continue indefinitely, and also that it may receive and convey the energy of radiation. The contact mechanism of its own particles resembles that of a frictionless gear; but where the intermediate ether is associated with matter, something like friction appears, as in the retardation of the velocity of refracted light in a dense medium.

The analogies pointed out by Wood are admitted to be speculative; but the recently acquired data concerning light-quanta, described in my paper on "The Luminiferous Ether," rest on a more solid basis, and these confirm Swedenborg's doctrine that light consists of spherical vibrating ether-particles whose "similar and harmonic motions may unite, and more powerfully move their mechanical organs; dissimilar motions may be reduced, as it were to their faintest forms." (*Principia,* II, page 218).

Every light-quantum, as it speeds through the aura, alternately grasps and releases a certain quantity of the aura vortically. The tendency of the magnetic aura to form vortex-filaments is explained by Swedenborg in the section of the *Principia* on "Causes and Mechanism of Magnetic Forces." On the supposition that the medium consists of minute vortex-particles, or "vorticles," he points out that these will tend to arrange themselves in rows with their axes in sequence and the motions similar, because there is then an absence of interference and resistance.

If two little magnets, A and B (Figure 5, copied from his Figure 3, *Principia,* Volume I, page 242) are surrounded by spheres of the magnetic aura, MN and OP, the latter must have the arrangement and motion of their vorticles in spiral lines from M to N and O to P, in order to be conjoined.

"If the currents of the spires, or the planes, are in the same parallellism, this is the state in which the motion of each is capable of being the best conjoined; and one vorticle may continue its gyration near another without any resistance or retardation. If therefore the vorticles are to be reciprocally conjoined, this conjunction must take place in the current and curvature of the spires." (*Ibid.*, pages 242-3.)

The direction ZK is a line of magnetic force along which all free magnetic particles will tend to set with their axes along its trend.

It is evident from the figure that the nearer A and B are to each other, the more nearly will the currents of their aural spheres coincide. Thus there is a strong tendency for A and B to approach each other along the line of force.

Reciprocating magnetic fields in the aura, an alternation of magnetic polarity, is an essential part of luminous progression. An inconceivably complicated enmeshing of vortex-filaments is involved in the process.

It may be asked: How can we be sure of the properties of a thing so apparently intangible as the aura? The reply is that these properties may be inferred from something like a mathematical expression which is admitted to be incomplete, but for which we may set an approximate value by eliminating those quantities which are obviously tending towards extinction, much as the mathematician does by the infinitesimal calculus.

The properties of the luminiferous ether formed out of the aura and based on its properties, indicate that it has directed, formal, or structural peculiarities which enable it to become the vehicle of the infinitely diversified forms of motion which constitute light. Some conception of this luminous diversity is exhibited in its partial analysis by the spectroscope, when we view the wonderful complexity of

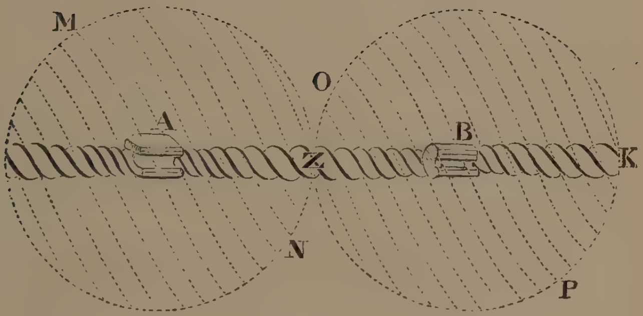

FIGURE 5.

the Fraunhofer lines in the solar spectrum; and the same variety continues throughout the much more extensive spectrum of the dark rays which are invisible, but which may be demonstrated by suitable means. There is precise formative detail everywhere throughout this spectrum. Groups of lines in endless profusion, and with every variety of breadth and intensity, are exhibited in this spectroscopic interpretation of radiant ethereal vibration. The lines vary from filmy gossamers which are barely to be detected, up to broad black bars, and from those with sharply defined edges to others whose widely spread, hazy margins can not be precisely limited. The latter under certain circumstances, as in the broad calcium lines called H and K, sometimes show a still finer structure—a wavy recurrence of orderly spaced, minor intensifications. Indeed, Michelson's interferometer shows that such subordinate structure in individual lines is quite common.

When the wave-lengths of the luminous vibrations which produce the spectral lines are measured, and the lines classified according to the chemical elements which emit the ether-waves of particular length, the further result appears, that these waves are related in many cases in a remarkable way, having wave-frequencies which form harmonic series of a special type with definite numerical intervals. Certain patterns or arrangements of these groups of obvious similarity are repeated in the spectra of chemically related elements. When the lines in these series are classified according to their character and the shifts produced in them by changes of pressure, they are found to fall in some of the simpler atoms (*e. g.*, those of the alkalies examined by Kayser and Runge into three groups, called principal, first subordinate, and second subordinate series. The individual members of the series are also in many cases close doublets or triplets.

The action of magnetism on nascent chemical atoms just released from chemical bonds, modifies their rates of vibration within narrow limits, and transforms single spectral lines, which otherwise have an invariable position in the spectrum, into close groups of peculiar arrangement, differing according as the wave-motion is viewed with or across the magnetic field; and it is found that the grouping produced in this magnetic (Zeeman) effect is different for each of the three spectral series mentioned, and varies also in the case of different elements.*

Besides these variations depending on vibratory frequency, we have changes in the form of the wave-front during double refraction by crystalline substances, and changes in the form of the luminous vibration wherever a light-wave becomes polarized, or intensified in particular transverse planes. In biaxial crystals, belonging to the orthothombic, monoclinic, and triclinic systems, there are three axes of elasticity along which there is propagation of light with as many different velocities. The combination and interference of three systems of unequally refracted rays produce the beautiful colored patterns seen in thin sections of such crystals when viewed by polarized light. Amorphous transparent substances, such as glass, are also isotropic dielectrics, and ordinarily have no double refraction; but they become electrically doubly refractive under the action of an electric strain, again demonstrating the close co-partnership of light and electricity which is another of Swedenborg's ideas. There is also a magnetic rotation of the plane of polarization of light during transit through certain absorbent media, depending on a rotation of the least parts of the medium which, while they vibrate in a magnetic field, are rotated thereby. These effects reside in the bound ether modified by association with matter. They result from the electromagnetic nature of light, and suggest that there is also an intimate relation between electromagnetic energy and the constitution of matter itself. They strongly suggest the reality of Swedenborg's theory of the intimate relation between successive orders of internal rotary motion in discrete particles.

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* There are also other and more complicated series whose details I must omit.

All of these diversities show that the ether is peculiarly a medium receptive of definite forms, and capable of passing them on without change. It individualizes motion and favors infinite diversity. It fully bears out Swedenborg's conception of particles receptive of innumerable modes of motion.*

Heat, on the other hand, seeks to diffuse itself into surrounding material, and to bring its whole environment into one common state of uniform temperature. This is accomplished by thermal conduction, as far as material conductivity for heat permits. The mechanism of thermal conduction in ordinary matter is conceived to be the passing on of an enhanced thermal state by transference from molecule to molecule by contact. The conduction of heat by solids is represented well enough by the somewhat empirical mathematical formulae of Fourier: but the thermal phenomena of gases required a new science—thermodynamics—for which we are mainly indebted to Clausius, although the names of Joule, Carnot, and Thomson (Lord Kelvin) will always be associated with its inception.

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* "The ethereal particles thus formed can subsist under any kind of motion, and with perfect aptitude to it." (Principia, II, page 203.)

In those bodies which are expanded by heat, and most bodies are so expanded, it was plausible to attribute the expansion and its accompanying increase of temperature to the increase of molecular velocity and momentum; but this can not be the whole story. The contraction of some substances, which goes on between limiting temperatures while the heat increases, indicates that there are changes going on within the molecules themselves, and that an increase of temperature is not solely increase of molecular momentum. Molecular impact in a heated body would soon bring the rectilinear motions of the molecules to rest, if they were not endowed with a perfect resilience. Whence comes this molecular elasticity? We conceive that at impact the molecule is distorted. The internal motions of the least parts of the molecule are disturbed and react upon the volume of ether which forms a part of the molecule. The ether being perfectly elastic, pushes back the disturbance and restores the form. But whence does the ether get its elasticity? We must admit the existence of some underlying source of energy more fundamental than the ether, and thus Hirn's contention that the ultimate nature of thermal energy has not been discovered when we have partially unraveled the mechanism of its flow, is justified.

The energy of heat is stored up partly in the kinetic energy of molecular rectilinear motion, on which sensible temperature depends, and partly in the kinetic energy of the vibratory or orbital atomic and electronic motions (latent and imperceptible heat) within the molecules, set up by the impacts. The accession of intramolecular energy is especially great when a body changes its state by increase of heat, and either melts or vaporizes. The name "latent heat" is sometimes restricted to the heat which disappears during change of state, but there is no valid reason for confining the term to what goes on at these points on the thermometric scale, since the same division of energy between sensible and imperceptible heat occurs at every stage of thermal increase. The ratio of the division of heat according to the relative values of the work required to change intermolecular and intramolecular motions, constitutes specific heat. The larger the amount of work which has to be performed to increase the movements within the molecules, the greater is the specific heat; but this does not explain the nature of energy, nor of that inertia of matter which enables energy to be stored as heat. It will eventually be necessary to fall back on the still more interior revolutions within the primal particles whose energy Swedenborg conceived to be "heat" of a higher order.

Besides these indications of structural relations between the ether and matter by which infinite diversity of form and the capacity of receiving energy are conferred by the ether and its underlying constituent aura upon matter, we must also examine the testimony of chemistry; and again we shall see evidence of two sorts: electrical properties on which form and structure depend (along with valency, affinity, vibratory frequency, etc.); and thermal properties which determine the relations of matter and energy, and which affect mass in the gross, or nonselectively.

SECTION D

THE CONSTITUTION OF MATTER IN ITS RELATION WITH HEAT AND LIGHT AS SEEN FROM THE CHEMICAL STANDPOINT

Swedenborg's theory of "elementary" particles, produced by vortical motion in the most finely divided substances of nature, predicates, as we have seen, three discrete degrees of atmosphere. He also speaks of three discrete degrees of heat and light. These terms, even at the present time, still remain to a considerable extent enigmatical. But a glimmering of comprehension begins to appear. We proceed to test these theories by a further comparison with some of the most recent work on chemical relations.

In a memorable address before the chemical section of the British Association for the Advancement of Science in 1886, its President, William Crookes, gave more definite shape to an idea which has been gathering strength from the time of Prout, that the chemical elements are derived from more primitive forms of matter. Faraday, Spencer, Lockyer, Brodie, Stokes, Graham, and others, have recorded their belief in the possibility or probability of such an evolution. Lockyer has gathered evidence from the lines of the solar spectrum, showing that many reputed elements are dissociated in the fiery atmosphere of our central luminary, or perhaps it would be better to say that these elements have never been formed in the sun. The idea is put forth that at different levels in the solar atmosphere, a succession of diminishing temperatures occur in receding from the center, and thus that elements which are dissociated by the heat of the deeper layers, are permitted to form in the outer strata. Possible fluctuations of solar temperature in the creative eras of the past may also have favored the abundant production of particular elements during periods of long-continued tranquillity, while others—the "asteroids among the elements"—have emerged into being during rapid but transitory thermal fluctuations. Some elements may be extinct, or present only in particular planets; but "all such changes must have been confined to that period, so remote as not to be grasped by the imagination, when our Earth, or rather the matter of which it consists, was in a state very different from its present condition [being still a part of the sun]. The epoch of elemental development is decidedly over." The periodic outbursts of light from the Cepheid variable stars, however, are now atributed, with much reason, to explosions attendant upon the formation and alternate destruction of unstable elements.

All the earlier attempts to dissociate or transmute the elements by chemical means having failed (though the newer radio-active transformations give evidence in precisely this direction and are most helpful); until recently we have been "driven to indirect evidence—to that which we may glean from the mutual relations of the elementary bodies. Such evidence of great value is by no means lacking." * In the first place, the atoms, as Herschel and Maxwell have pointed out, "bear the impress of manufactured articles. . . . A manufactured article may well be supposed

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* This difficulty seems to be on the verge of removal, since Ramsay has produced minute amounts of several elements by transformation of other elements. Anderson, by concentrating a very powerful electric discharge upon a fine wire of the refractory metal tungsten, caused it to explode. After the explosion nothing was found but a little helium gas. We must conclude that the metal had been completely converted into helium, very probably reversing the process by which the metal was originally formed out of helium in the sun. From the conditions of the experiment, the temperature of the exploding wire is estimated to have been 50,000 Centigrade degrees. The hottest stars show no lines of the heavier metals in their spectra. This was at first supposed to mean that, though these metals might be present, the conditions were not favorable for the production of their line-spectra. From Anderson's experiment, it now appears more probable that the internal velocities of revolution of the electrons in the heavy atoms exceed that of stability at these very high temperatures. The electronic rings expand and the atom blows up. It is not a case of simple ionization by the loss or gain of a few supernumerary electrons, but one of a complete disintegration of the atoms. In favor of the supposition, the abundance of helium in the hottest stars is to be noted. Yet it is not proved that the helium exists as such within the atoms of tungsten. The electric excitation of the atoms in the tungsten spark gives no spectral lines having any relation to those of helium. The explosive disintegration is more profound than that of the spark.

to involve a manufacturer, but it does something more; it certainly implies a raw material." Prout's hypothesis that the atomic weights of the elements are exact multiples of that of hydrogen, and indicate derivation from that substance, becomes increasingly probable. Elements of discrepant atomic weight, involving fractions of the atomic weight of hydrogen, such as chlorine (atomic weight, 35.46) and magnesium (24.32), are now found to consist of two or more isotopes with weights in exact multiples of that of hydrogen, combined in definite but fractionally incommensurate proportions. But it is not necessary to suppose that the hydrogen atoms retain their individuality in the complex. Their energy is redistributed.

An argument in favor of a common derivation, is the occurrence in close juxtaposition as to their position in the series and chemical properties, of certain elements which have a common family resemblance, such as the members of the platinum and palladium groups, and the numerous allies of yttrium, all of which suggest phenomena resembling allotropy.

The analogy between the hydrocarbon radicles and elementary substances, has been pointed out by Professor Carnelley. Secondary elements built up from a series of compounds of two primaries, should exhibit periodicity and some features agreeing with those of the odd and even series of Mendeléeff's classification. Pelopidas compares the valency and the oxygen compounds of a series of hydrocarbon radicles with the members of one of Mendeléeff's periods, finding close resemblance. The series:

Radicles,	C_6H_{13}	C_6H_{12}	C_6H_{11}	C_6H_{10}	C_6H_9	C_6H_8	C_6H_7	C_6H_6,
Atomicity,	1	2	3	4	5	6	7	8

is followed by the aromatic radicle C_6H_5 which repeats many of the properties of C_6H_{13}, and is likewise a univalent radicle.

Polymerization has also been invoked to explain the derivation of elements by the continued addition of a primary subatom. Carnelley shows that successive mmbers of a Mendeléeff group frequently differ in their atomic weights by about 23, which is the atomic weight of sodium. The "triads of Dobereiner" (noted *ante* Chapter IV., page 107) are another instance. The process of doubling up, if continued beyond the atomic stage of development, yields allotropic varieties of the elements. Thus the molecule of sulphur which, at high temperatures, is composed of two atoms, changes to one of six atoms at a lower critical temperature, forming a polymeric modification of sulphur, from which arise the complex molecules of the metallic polysulphides. Extending the process backwards, since oxygen and sulphur have atomic weights of 16 and 32 respectively, and also resemble each other in many of their chemical properties, it is a natural inference that there is in these elements a similar relation of subatomic "polymerization," but here with a more perfect coalescence.

Heat is given out abundantly in the transformation of sulphur at the critical temperature and partly reverses its polymerization, and this in large masses ought to cause periodic thermal fluctuations. Dr. Mills assigns this as a cause of the periodic light changes in some of the variable stars, inferring that they are an evidence "of the genesis of elementary bodies."

Another indication of continuity in elementary evolution from simpler forms of matter combined with a law of systematic variations in the process, is furnished by Professor Emerson Reynolds' method of illustrating the periodic law discovered by Mendeléeff. In Reynolds' scheme as modified by Crookes, the elements are arranged along a gradually contracting lemniscate spiral, representing the dying oscillations of a compound pendulum, following each other in the order of their atomic weights, (and subtly suggesting the alternating throw of some great engine) and forthwith a systematic relationship is found to exist between members of the series symmetrically placed. Bodies possessing analogous chemical properties are found one above another. The intensity of chemical activity diminishes as we recede from the initial line of no weight, and also on either side of the central nodal line of the pendulum's vibration, as if thermal energy were being lost in the production of the more complex forms. The primitive half-swing, and all subsequent half-swings on that side, contain the elements belonging to Mendeléeff's even periods, which are often paramagnetic. The alternate half-swings contain the members of odd periods which are diamagnetic. Each half-swing contains seven members, varying from strongly electropositive through neutral to strongly electronegative, the sign changing suddenly at the node, where a new zero group has been added in the recently discovered inert or "noble" gases, so called apparently because, like certain human beings, they never do anything useful! This electric change is accompanied by a corresponding change of valence.

Thus, in the first half-swing, we have:
Helium (valency zero, chemically inert),
Lithium (univalent, strongly electropositive),
Beryllium (bivalent, less strongly electropositive),
Boron (trivalent, mildly electropositive),
Carbon (quadrivalent, nearly neutral),
Nitrogen (quinquevalent, moderately electronegative),
Oxygen, (sexivalent, strongly electronegative),
Fluorine (septivalent, very strongly electronegative).

In Mendeléeff's periodic scheme, the elements are arranged approximately in the order of their atomic weights, and except for some aberrant forms and missing links, they fall into twelve periods, each consisting of eight regular members.

Mendeléeff's eighth, or aberrant group, consists of three sets of triplets: Iron, cobalt, nickel; ruthenium, rhodium, palladium; and osmium, iridium, platinum. The members of each triplet have nearly identical atomic weights and closely related chemical properties, and have often been regarded as varieties of a single substance. Closely adjoined to the significant trio—copper, silver, gold—we are impelled to seek for some special correspondence in this trine of trines. "These bodies are 'interperiodic' both because their atomic weights exclude them from the small periods into which the other elements fall, and because their chemical relations with certain members of the adjoining periods show that they are probably interperiodic in the sense of being transitional." Other extra or intermediate varieties are suspected among the metals of the rare earths which are difficult to separate on account of their chemical resemblance. In the spiral arrangement suggested by Crookes, the three triplets take their places near three of the ten nodal points. When spirally arranged, the alternate members of each of the eight regular groups are further separated into two series, which the chemist recognizes at once as the familiar elementary groups possessing allied chemical properties.

To account for these relations, Crookes imagines a primeval protyle, containing within it "the potentiality of every possible proportion or combining weight." Out of this, the simpler elements which include all of those most essential to life, were formed; but the more complex did not appear until towards the close of the creative epoch. "With hydrogen of atomic weight equaling unity, there is little room for other elements, . . . but what if we get 'through the looking-glass' and cross the zero-line in search of new principles, what shall we find on the other side of zero? Dr. Carnelley asks for an element of negative atomic weight. Here is ample room and verge enough for a shadow series of such unsubstantialities."

Such speculations which, in 1886, seemed permissible to Crookes and to Carnelley, would today be considered quite unnecessary; because the only ground for such theorizing, which was the perception of the need of a substance very much lighter than hydrogen to explain certain small fractional departures of the atomic weights from exact multiples of the weight of hydrogen, is now swept away by the discovery of the tiny electron. But Swedenborg's perception that, back of even this, must be a still finer, but wholly weightless substance with increased creative potencies, is not overthrown, but stands forth even more urgently.

> To the solid ground of nature,
> Clings the mind that builds for aye,

sings the poet Wordsworth. The sentiment is useful, if the "solid ground of nature" means the facts of experience, but is wholly fallacious, if power is imagined to reside in "solid" inertia. Swedenborg traced the very source of power to the successive accessions of more and more vigorous internal motion in substances which progressively put off the material.

In *Arcana Coelestia,* n., 5658, we read: "Weight in the natural world corresponds to good in the spiritual world; and extension, to truth. For in Heaven . . . there is neither weight, nor extension . . . there do indeed appear things heavy and extended with Spirits, but they are appearances originating from the states of good and truth in a higher Heaven." *A. C.*, n. 8298, says: "It is evil which makes weight in the spiritual sense and which thus sinks down as from its weight; but not falsity, by itself; but from the evil which is in it; for falsity from itself has no weight."

That is, the gravitational properties do not involve truth, or the spiritual, but either good or evil. And in treating of gravitational attraction to the center of the earth, Swedenborg says (*Apocalypse Explained*, n. 159): "This center of gravity is merely nature's center of gravity; there s another center of gravity in the Spiritual World; and his, with man, is determined by the love in which he is; downwards, if his love is infernal; upwards, if his love s heavenly."

In spiritual correspondence, the lighter elements, which are the only ones which are useful for the production of hose organic substances which minister to life, represent heavenly principles. The correspondence of particular subtances is derived from their uses. Physical properties can be foreseen to a certain extent from the position of an element in the periodic series; but it is doubtful whether the *use* that can be made of anything can be determined by any other than the experimental method.

Iron corresponds to natural truth, because it can be used for hard, cutting instruments which divide and expose the real qualities of things. It represents inflexible natural-law which prescribes penalities for its violation. "Do not play with edged tools." Gold is too soft for this, but as it cannot be corroded, it stands for genuine, gentle good-of-heavenly-love. It is so used in the letter of the Word of God. *"I counsel thee to buy of Me gold tried in the fire, hat thou mayest be rich*, signifies admonition to procure o themselves the good of love from the Lord through the

Word, that they may be wise." (*Apocalypse Reveale* n. 211). "Gold tried in the fire" is a symbol of perfe virtue. Silver is splendid for mirrors, hence it has it relation to those reflective processes by which the spiritu mind is illuminated.

Gold stands for the heart's best love, because it is incorruptible, but not because it is heavy, for that, as we hav seen, if it stood alone, would convey quite a different symbolism. Gold and platinum are exceedingly permanent, bu radium and its congeners are evanescent. Yet all are heavy In general, since the heaviest substances are found to b radio-active and unstable, we may infer that great weigh contains a representative of the merciful law of Divin order by which evil has within it the germ of its own destruction.

Carnelley's hypothesis of a sub atom of negative weigh has never been confirmed, but there can be no doubt tha a certain quantity of electricity, associated with a definite volume of the bound ether, enters into the composition o every atom. A portion of this electricity exactly proportional to the valency, or atom-grasping power exhibited by combining atoms, may be temporarily separated from the atom while it is undergoing chemical changes such as occur in the electrical deposition of metals, dissolution of solids in liquids, decomposition and recomposition of salts—the electricity remaining free during the transition period; and this separable atomic electric charge is the same for all atoms of like valency, whatever their atomic weight. It is a significant fact that, as Faraday showed, "every monad atom has associated with it a certain definite quantity of electricity; every dyad has twice this quantity associated with it; every triad three times as much, and so on" (Lodge). In addition to this separable electric charge, ery atom contains specific neutralized electric charges, *e.*, of opposite sign and equal quantity, from which it ever parts. This permanent electric quantity is very much eater than the other.

The mass of the atom is proportional to the sum of the tal electric charges of both sorts, and we may believe that e force of gravity is entirely dependent on some action this definite electric quantity, probably a pulsating one. oth the gravitational energy of an atom and the electric eld of an electric charge reside in the surrounding aura. J. J. Thomson's view, the electric action in the medium like that of a columnar vortex. Lines of electric force, erefore, are such vortices in the aura. They are to be stinguished from the constituent vortex-particles and rtex-filaments of the aura itself. Lines of normal aural ws being bent aside by the columnar electric vortex, some the filaments loop and are cut off, forming an attached velope controlled by the vortex. This reminds us of the echanism devised by Swedenborg in his hypotheses to plain electric attraction, which predicated the suction of whirling movement.

THERMO-CHEMICAL RELATIONS OF THE ELEMENTS

One more piece of evidence will complete the chemical gument in respect to the purely thermal properties of atter. In every chemical change, heat appears or dis-pears. Thus Thomsen found that in the production of o grams of hydrogen by solution of metals in hydro-loric acid, the following amounts of heat are evolved:

Lithium	125,860	heat	units
Potassium	123,700	"	"
Sodium	114,380	"	"
Magnesium	108,290	"	"

Aluminum	79,880	"	"
Manganese	49,360	"	"
Zinc	34,200	"	"
Iron	21,310	"	"
Cadmium	17,610	"	"
Lead	4,130	"	"

We see that the elements have peculiar thermal as we as electric capacities, though the two follow different law and that with few exceptions, the heavier metals have th least heat to spare. The swing of the pendulum of th evolutionary clock is diminishing as the complexity of th atoms increases. There is, however, a unity in the therma law, contrasting with the striking periodicity of the electr properties of the elements; but a more extensive serie involving the relation between the melting points of th elements and their atomic weights, shows that there is als a subordinate periodicity in the thermal sequence.

FUSION TEMPERATURES
(Absolute Centigrade Degrees)

Mendeléeff's Periods	*High*		*Low*	
Period 2	Carbon	> 3873° K	Oxygen	55°
Period 3	Silicon	1693	Argon	85
Periods 4 to 5	Titanium	2063	Krypton	104
Periods 6 to 7	Tirconium	1973	Xenon	133
Periods 10 to 11	Tantalum	3123	Mercury	234

Within a given period, the elements having relative condensed atoms are the hardest to melt. The most in fusible substances are carbon and boron with atomic vo umes of 4.0 and 4.2; while the fusible alkali metals, pota sium, rubidium, and caesium, have atomic volumes 46. 56.4, and 70.2.

The laborious work of Dr. Larmor in which he invest gated the properties of a molecule, regarded as a system of electrons in orbital revolution, the spectral lines being produced by "epicycles superposed on the main orbits of the various electrons in the molecule," was perhaps a necessary preliminary to a true theory of molecular constitution, as the Ptolemaic epicycles which furnish the suggestion, were needed for the development of the Copernican system; but like its astronomical predecessor, the hypothesis had a flavor of artificiality. The speculation marches along with mechanical precision, but the effort to account in this way for actual spectra, leads to a piling of epicycle on epicycle like that which broke the back of the Ptolemaic system.

On the other hand, the vortex theory as developed by Helmholtz, J. J. Thomson, Hicks, and others, and especially some of its unique forms first proposed by Swedenborg, bears on its face all the signs of a natural system. It has enormous difficulties which task the human intellect to the utmost. Its development leaves huge gaps still to be filled; but every now and then it comes in touch with nature and gives luminous bursts of insight and suggestion as to natural phenomena, which compel assent and assure us that the investigation is on the right track.

In all of these respects, the work of W. M. Hicks ("Researches in Vortex Motion, Part III. On Spiral or Gyrostatic Vortex Aggregates," Proc. Roy. Soc., London, Vol. LXII, page 332, 1898) is especially noteworthy. The general conception is that of "vortex filaments in the shape of helices lying on concentric cylindric surfaces." There may be return filaments and spherical aggregates. The system suggests the theory of an infinitely complex aura of interlacing vortex-filaments whose ordered arrangement constitutes matter; but the theory is here developed mathematically from the assumption of a hypothetical irrotational ether. The author makes no attempt to conceal this incongruity which flows from mathematical difficulties, but holds out the hope that many of his deductions would remain true if a more complete theory were substituted. In my paper on "The Luminiferous Ether," I have pointed out a mode of reconciling this conception with facts of thermo-chemistry. Hicks finds that at certain critical surfaces the stream lines, or actual paths of the particles, and the vortex lines, or lines of twist, change places, thus giving to the compound vortex, or vortical aggregate, alternating properties which immediately suggest some of the periodic alternations in the physical and chemical properties of the elements.

"Suppose the attempt made to obtain sets of aggregates with greater and greater angular pitch [of the stream lines]. It will be found that as the external pitch of the stream lines increases, the equatorial axis [of rotation in the vortex ring] contracts, and the surface velocity diminishes. On the outer layers (ring-shaped), the spiral pitch is chiefly produced on the inner side facing the polar axis, until on the boundary itself the stream lines lie along meridians and the twist is altogether on the polar axis. The pitch can be increased up to a certain limit. As this is done, the stream lines and the vortex lines fold up towards one another, coincide at a certain pitch, and exchange sides. When an external angular pitch of about 330° is attained, it is impossible to go further if a simple aggregate is desired. If a higher pitch is desired, the aggregate splits into two concentric portions—an inner spherical portion, and an outer shell. The central nucleus is similar to those just described. It produces a part of the required pitch. The outer layer has spirals with the same direction of twist, which complete the balance of the pitch. In these, however, the motion is in the opposite direction. With increasing pitch this layer becomes thicker, and its equatorial axis contracts relatively to the mid point of the shell until another limit is reached; the stream and vortex lines again fold together, cross and expand as this second limit is reached. If a larger pitch still is desired, there must be a third layer, and so on." (*loc. cit.*, p. 333-334).

Speaking of vortex-atoms, this author says: "The results of the paper refer only to spherical aggregates, that is, all the various elements are compared, not when their energies are in thermal equilibrium, but in the artificial association such that the energy of each particular element is that which is necessary to give it a spherical shape." (*loc. cit.*, p. 336).

If these principles are to be applied to the atom, the motions described by Hicks must be those of energy in the aura or of Swedenborg's inmost degree of heat. But associated with these motions are those of groups of electrons which continue in steady orbital motion, included within the folds of the former, but on a less complicated plan.

Comparing the properties of these vortical aggregates with those of Mendeléeff's periods in the chemical elements, it is found that "the metals [in the second and third periods] belong to aggregates having an even number of layers or axes, that is, the outer rotational motion is opposite to that at the center." We have seen (Chapter IV, pages 115, 130) that there are probably opposite electronic revolutions within the atom as well as others with the same direction; but it will take much investigation to clear up the relations between these and the thermal and magnetic properties of the elements.

"The nonmetals belong to aggregates having an odd number of the same, that is, the outer rotational motion is in the same direction as that at the center.

"In the even series of elements (series 4, 6, 8) the vortex lines lie between the stream lines and the meridians [of the inner sphere] or, as we may express it, the stream lines lie farthest out.

"In the metals of the odd series, the stream lines lie between the vortex lines and meridians, or the vortex lines are the outermost." (*loc cit.*, p. 337.)

"Having fixed their general position, we may now compare with the curve giving the atomic volumes. When this is done, it is found that . . . the metals of high fusibility have their stream and vortex lines nearly coincident. The alkalies have their outer layer thin, the calcium group thicker, and so on. . . . The atomic volume marches with the moment of angular momentum of the aggregates [in which, owing to the alternation of positive and negative values, the total moment increases and decreases.] In other words, the moment of momentum due to the gyrostatic effect rises and falls with the volume of the atom."

"All that is yet known respecting the stability of vortex rings leads to the conviction that it is not open to us to explain the various densities of matter as we know it, by different densities in the material composing the vortex-atoms themselves. We must suppose the matter of all atoms to be the same material as the ether itself, [*i. e.*, what Swedenborg calls the aura.] The masses must therefore be proportional to the volumes. [To this conclusion, objection must be made if, as appears probable, gravitation originates in particles subsequent to the aura.] It follows that atomic volumes, as ordinarily understood, must depend on the spaces occupied in solid bodies by their atoms. Now a ring will clearly take up more space than a sphere of the same volume, and we ought to expect high atomic volumes to go with large aperture rings. Combining this with the ast result, it would follow that moment of momentum rises nd falls with the equatorial diameter of the ring atom, hich is a highly probable result." (*loc. cit.*, p. 337).

This appears to be an effort to still maintain the Kelvin tom, formed on the plan of a smoke-ring in air. The alernate rise and fall of the atomic volumes, when the mass ncreases progressively and regularly, contradicts the asumed proportionality, unless the "mass" and its proporionate "volume" are supposed to refer to the mass and olume of the contents of the anchor-ring of revolving subtance, that is, revolving around the *circular* axis. In this ase the same amount of revolving substance might give a ing of any aperture whatever. But here the "atomic volmes" are identified with the apertures of the rings. It eems to me that there are obvious difficulties in the exlanation, and it is a departure from the fundamental roposition that we are dealing with "spherical aggregates." y hypothesis of the addition of successive shells of elecrons to the growing atom is not subject to this objection. ere the internal moment of momentum of the revolving ura which produces the mass of each individual massiving electron, does not fluctuate; but the interval or tra-atomic "thermal energy" (which I have provisionally entified with Swedenborg's "second degree of heat"), and hich is due to the orbital revolution of the electrons within e atom, does fluctuate according to the dimensions of e orbits, or with the speed of the electrons, and this is mmed up in the Lothar Meyer curve of atomic heat.

Hicks attempts to cover too much ground when he inudes in a single vortical scheme (which is admitted to rest pon a mathematical fiction) the thermal properties of the ements, some of the properties peculiar to the smoke-ring air, the volumes of the atoms, and even gravity. Swedenborg also tries to cover too much ground when he makes a single species of vortical motion apply to particles of several orders of magnitude. Though Swedenborg's theory seems to fit well with a vortical electron, all of the evidence points to a different plan for the atom which appears to be a swarm of electrons with very diverse motions, none of them strictly vortical. If the evidence brought forward in my paper on "Atomic Structure" (Publications of the American Astronomical Society, Vol. IV, p 291) is accepted, we may regard an atom as a series of concentric whirls of electrons of a spherical shape, including other electrons endued with various peculiar motions. The whole may very likely be surrounded and interpenetrated by a composite vortex in the aura of the Hicks type. Whether the energy of this composite vortex constitutes Swedenborg's "third degree of heat," or whether this applies rather to the energies of the individual particles of the aura considered separately, is perhaps an open question.

The volume of the sum of the electronic vortices in an atom does not fluctuate under ordinary circumstances, and is proportional to the mass, and thus the gravitational proposition of Hicks may be true, but not in the sense which he intended. Exception may also have to be taken when the orbital speed of an electron approaches that of light, since its mass then increases, as if the volume of the electron had grown smaller and the electric condensation and power more intense. However this may be with vortices in the aura, electrical forces favor the spherical form. But possibly the two may be associated without conflicting.*

The vortex imagined by Hicks resembles the vortex-particles which Swedenborg ascribed to his primitive atmospheres, with the difference that the latter particles do not proceed beyond a first limit in which a thin layer having coincident stream and vortex lines is supposed to circumscribe the motion of the contained active particles of a finer order. It is obvious that the structure of an atom is not as simple as this. The hypothesis of Hicks assumes motion in a continuous fluid, and consequently the movement can not stop sharply at a definite boundary which may be called the surface of the particle. Swedenborg avoided this difficulty by imagining a composite particle with a superficies composed of polar particles of a finer order, all in rapid rotation, and kept in juxtaposition by their identical movements at points of contact. "Elementary particles cannot be in contact," he says, "except in a manner accordant with the motion of their surface and their figure." (*Principia,* Part 1, Chapter 6, Article 33). "Their situation is in a spiral form, and similar to the situation of the parts in every finite. . . . As they run into a spiral, . . . they are simultaneously moved in accordance with this general fluxion. . . . It is at the poles principally that the parts are in contact." (Article 34.) If "displaced from their situation, . . . they immediately return to it as their natural one." (Article 38.) "From the motion of a volume of the particles exists their vortical motion." (Article 37.) "Upon the exercise of the slightest force they naturally flow into a vortical motion. . . . One particle, as it were, assists another in the performance of the same gyre." (Article 38.)

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* Compare my paper, "Tourbillons Galactiques et Atomiques" (Bul. Astron., Tome I, Fasc. 2, 1921), also ante Chap. V.

The motions of the component particles gradually inflect themselves towards the axis of the compound particle, "until the vortical motion terminates in a right line, and so vanishes in a direction parallel with the axes of the particles. . . . The greatest motion is nearest the center [of the compound particle], and the least at the outermost peripheries." (Article 39.) This agrees closely with the limiting case described by Hicks (*loc. cit.*, p. 334), where "the spiral twist is chiefly produced on the inner side facing the polar axis until on the boundary itself the stream lines lie along meridians and the twist is altogether on the polar axis."

In Swedenborg's compound particle the "superficial matter or finites, flowing through a surface, may, near the poles, pass into the surface of a neighboring particle" (Article 40), but otherwise the surface pellicle retains its individuality, except that on the rapidly revolving polar core, some of the particles are thrown off by centrifugal pressure, and passing out from the core in spiral paths until reabsorbed in the outer nappe of the pellicle, they form part of the volume of inclosed actives whose pressure keeps the compound particle distended and gives it elasticity.

To preserve the mechanism indefinitely, it is further necessary that alternate vortex lines of the pellicle shall have opposite rotations, although this point is not mentioned. The particles described in the preceding quotations from the *Principia* are not those of ordinary matter, but belong to the first or universal atmosphere of the natural world. "It is in virtue of this universal element that all things in the starry system appear as it were present. Whenever they do not appear so, it is only in consequence of our being accustomed to measure distances by comparing the angles made by distant objects with those immediately proximate to the eye. It is in virtue therefore of this element, that we can contemplate the remotest stars, as also the planets by their reflected light." (Article 50.) The first element in its initial phase is therefore identical with the aura, out of which is formed what we now call the luminiferous ether, although Swedenborg imagined its particles to be successively compounded to form the media which he calls the aura and the ether, the seat of magnetic and electric forces respectively. I have elsewhere suggested modifications by which these hypotheses can be reconciled with recent discoveries (see Chapter IV). His reason for this further complexity was that magnetism can penetrate through obstacles which prevent the passage of electricity or light, whence he supposed that the particles of the magnetic atmosphere must be smaller in order that their vortical flow might pass unimpeded through the barriers. Science does not at present make this distinction, although it appears reasonable and the evidence of structure in the ether certainly implies the existence of a more fundamental medium to which the name of aura may be given, reserving that of ether for the electronic atmosphere so closely associated with matter.

Besides the probable connection between the vortical flow of a primitive atmosphere and thermal properties, there is further evidence of a relation between heat and mass. Professor Carnelley has obtained "An Approximate Algebraic Expression of the Periodic Law in the Chemical Elements" (Phil. Mag., (5) Vol. XXIX, p. 97, 1890) which yields the further information that, just as a constant amount of electricity enters in multiple ratios into the composition of every atom giving valency and other properties, so a definite quantity of thermal energy successively appears or disappears in the transformation of one element into another.

Let the atomic weights be stated as multiples of the weight of the hydrogen atom. If $A =$ the atomic weight of an element, $v =$ the maximum valency of its atom, or its group number in Mendeléeff's periodic law (that is, the maximum number of hydrogen atoms, or an equivalent, with which the element can combine), m_2 to m_{12} being numbers depending on the periods denoted by the subscript numbers, and $c =$ the atomic heat, or the product of atomic weight multiplied by specific heat, the following relations are found to hold for the entire series of chemical elements:

$$\text{Atomic weight} = A = c(m + \sqrt{v}),$$

$$\text{Specific heat} = \frac{1}{m + \sqrt{v}}$$

$$\text{Hardness} = \frac{1}{\text{specific volume}} = \frac{\text{atomic weight}}{\text{specific gravity}}$$

$$= \text{Specific gravity} \div [c\,(m + \sqrt{v})],$$

in which m is a member of an arithmetical progression, increasing by 2½ for the second and third periods, noted by Mendeléeff as exceptional, but by 3½ for the rest, except in the aberrant eighth group, where m increases by $2 \times 3\frac{1}{2}$, and v must denote the numerical order of the elements in each triplet with values $v = 8, 9, 10$, respectively, instead of $v =$ valency.

The values of m are as follows:

$$m_2 = 0,\ m_3 = 2.5,\ m_4 = 5,\ m_5 = 8.5,$$
$$m_6 = 12,\ m_7 = 15.5,\ m_8 = 19,\ m_9 = 22.5,$$
$$m_{10} = 26,\ m_{11} = 29.5,\ m_{12} = 33;$$

and for the eighth group, the values of m coincide with those for the 4th, 6th, and 10th periods. The corresponding values of c for the iron, palladium, and platinum triplets are 7.2, 7.0, and 6.7; but for the remaining elements, $c = 6.6$, which is the atomic heat, if specific heat is determined between 0° and 300° C. Specific heat is not strictly a constant, and hence this determination can not be made exact in the absence of a criterion of temperature at which specific heats are normal.

If we are to admit that electricity is the fundamental of matter and an energized substance entering into the composition of every element, we must be ready to accept a thermal derivation as well. If there was a truth underlying the alchemist's dream of "transmutation," there may have been equally a germ of fact under the notion of "phlogiston." The march of knowledge is like the swing of the pendulum or the evolutionary cycles of elemental creations. Let us retrace our steps towards a new "alchemy." The time is propitious. The hand on the dial of the ages points to a new day.

THOMSON'S DISCOVERY OF THE COMPOUND NATURE OF THE ATOM

The first experimental demonstration that the atom is compound was made in 1899 by Professor (now Sir) J. J. Thomson through the memorable discovery that the cathode rays projected from the negative electrode of a vacuum-tube, consist of corpuscles, or negative electrons, having a mass between 1/800 and 1/1000 that of the hydrogen atom, later more exactly determined by Milliken as 1/.1845. As the dimensions of these minute bodies do not vary notably when the material of the electrode or the gaseous content of the tube are changed, Professor Thomson concluded that atoms of every kind are composed of the same corpuscles in numbers proportional to the weight of the atoms. Thus if the hydrogen atom contains 1845 corpuscles, the atom of mercury must include a little over 200 × 1845 = 360,000 electrons.*

Since each electron carries a permanent definite charge of electricity, or acts as if it were composed of a measured quantity of that electric substance which, as Swedenborg and Franklin taught, flows in the lightning, and pervades all matter, the corpuscles repel each other, if of the same sign and the negative ones can only be retained in permanent aggregation to form the atom, by the overmastering attraction of a positive charge. The positive ion acts as if it were such a charge; and since the diameter of the atom is immensely greater than that of the negative electron, the combination may be likened to a solar system, the positive charge either remaining in the center like a sun, or, as Thomson at first supposed, it is distributed in a sphere of attraction which determines the size of the atom; while the negative electrons either revolve or oscillate around the central positive charge, or else the positive charge encloses them. Since the negative electrons, unlike the planets, mutually repel each other, it is probable that their mutual relations determine their precise positions. Whatever internal forces arise from the energy of the revolution of electronic spherical shells within the vortex-aggregates, the forces may be expected to rise and fall with the variation in the number of shells and their speed of revolution. Exactly such fluctuations to the number of six are shown in the most informing "Fifth Paper on Atomic Structure" by Messrs, Harkins and Hall (Journal of the American Chemical Society, Vol. XXXVIII, p. 194, February, 1916) from which the curves in Figure 6, copied after their Figure 8, are taken. Without considering a few minor variations which are seen as subordinate "shoulders" on the slopes of the principal fluctuations, the curves representing compressibility, atomic volumes, coefficients of expansion, and reciprocals of the absolute melting points of the elements (all of them being thermal functions) rise and fall in a series of waves. Quite similar is a curve of "atomic conductive capacity," given by Benedicks (Jahrbuch d.

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* I have shown that the heavier atoms must contain similar large numbers of mass-giving electrons. See my paper on "Atomic Structure."

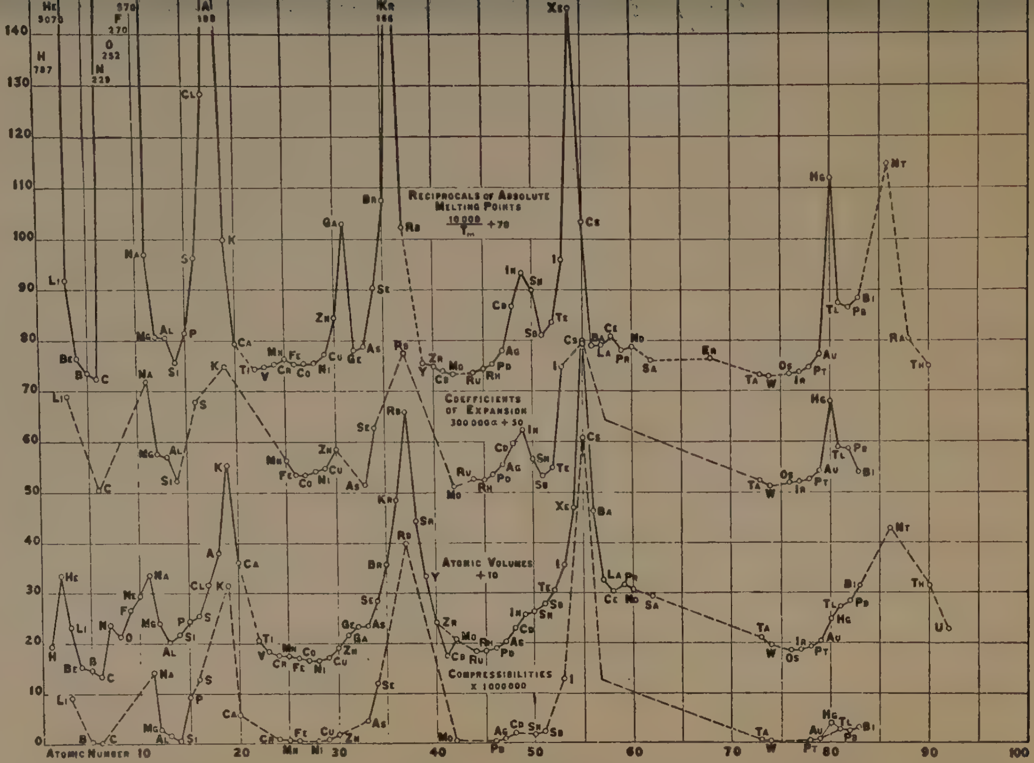

Fig. 8.—Cohesional properties of the elements. (The atomic volume of Cb is probably not correct.)

FIGURE 6.

Rad. u. Elektronik, Bd. XIII, p. 362, 1916), where electric onductivity (known to be dependent in some unexplained vay on heat) is shown to undergo fluctuations nearly paralel to those of the above thermal curves.

Benedick's curve is cited by Dr. Vegard in his paper n "The X-Ray Spectra and the Constitution of the Atom" Philosophical Magazine (6) Vol. XXXV, p. 323, April, 918), and is compared with the periodicity which he finds n the X-ray spectra, where, for example, in that of zironium (atomic number = 40), the lines in its *K*, *L*, *l*, nd *M* series are attributed to perturbations of the followng revolving electrons:

ays	No. of Electrons in Ring	Radius of Ring
-rays	3	1.34×10^{-10} cm.
-rays (principal)	7	6.08 "
-rays (subordinate)	8	7.76 "
-rays	10	25.4 "

ight more electrons may be assigned to a subordinate ing, giving *m*-rays, and four to the next principal ring rom which proceed *N*-rays completing the number 40 for his element; but their spectra are not easily observed owng to crowding and overlapping. Still other rings of revoling electrons are foreseen for the heavier atoms, where, owever, on account of the large mass, greater condensaon, and excessive rapidity of revolution of the electrons hich emit the fundamental rays of the X-ray spectrum, bservation becomes difficult. The rings of zirconium, as ar as they have been observed, are shown in Figure 7 from egard's Figure 1. The radii of the rings increase outardly in harmonic progression, and the wide gaps between hem suggest that here is where the successive spherical hells of revolving mass-giving electrons are situated, and hat the electrons of the X-ray spectra revolve equatorially in the spaces between the shells, being perhaps preserved in this situation by a magnetic control, but with a very delicate adjustment, since they are the first to be set vibrating under bombardment by cathode rays. A difficulty in respect to Dr. Vegard's interesting hypothesis is that the visible spectrum of hydrogen appears to represent *L*-rays, and the infra-red spectrum, *M*-rays and *N*-rays, requiring at least four electronic rings, where hydrogen is supposed to have only one.*

By exception, the additional chemical electrons of the rare earths do not take the cubical position, but form rings (equatorial or subequatorial?) like the rings of nebulium, protofluorine, etc., and therefore exhibit no change of valency. These "chemical" rings may even revolve, since the rare earths are the most paramagnetic of the elements except those from manganese to nickel. The revolution may also be the reason why some of these elements, by exception, emit line-spectra from their incandescent solids.

Recent researches have indicated the desirability of a regrouping of Mendeléeff's twelve simple groups. There is first a series of the lightest elements: Hydrogen, coronium, nebulium, protofluorine, and perhaps one or two more, where the extra electrons either oscillate or revolve in an equatorial ring (Langmuir is of the opinion that not more than two can *oscillate.*) Here the increase in the number of electrons in the ring does not alter the valency. The disturbance of electrons of the ring of nebulium takes no more energy than that of the electron of hydrogen. From helium onward in the classification of the elements there are three paired "cycles" of increasing complexity, containing respectively 4^2, 6^2, and 8^2 elements, at least in theory, though gaps appear among the heaviest ones, probably in-

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* For the explanation which has been proposed see page 138.

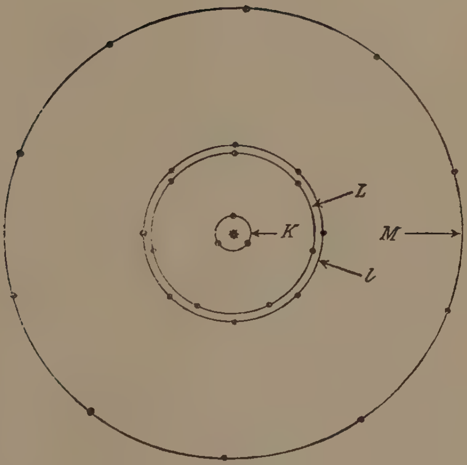

FIGURE 7.

dicating that such atoms are unstable. Added electronic shells, wider compartments, more complicated arrangements of the supernumerary electrons, and greater complexity of their line-spectra characterize the heavier atoms. The simple etherion can mirror every variety in this internal perturbed motion. Spectroscopic research fills in the details.

It is worthy of note that each addition of one electron to the Moseley number of revolving electrons in the formation of a new element, is made to an outer ring, and that the inner rings, both as to number, relative lengths of radii, and electronic constitution, suffer no other change, after they are once formed, than a general diminution of the absolute values of the radial lengths from condensation as the mass accumulates, and a certain central attractive power increases. Thus zirconium and mercury have about the same atomic volume; but mercury (Moseley number = 80) has a larger number of rings than zirconium (Moseley number = 40), and the radii of the corresponding rings (K, or L, or M) have to be shorter for mercury than for zirconium.

Since the force which retains the electronic rings and causes them to revolve is an *electrical attraction,* we have to assume that for each negative electron added to the rings, a positive electron is added to an inmost positive nucleus. Thus there seems to be no escape from the predication of still a third "Moseley number"! At least, this is implied by the accepted axiom that every negative electric charge corresponds to an equal positive charge. The charges may be violently separated, in which case the negative electrons are sent speeding through space with a velocity but little less than that of light; but if permanently associated, the electric charges must be very near to each other. All that keeps them apart in the atom is the centrifugal force of the electronic revolution. The electrons of the nucleus are presumably closely conjoined by their attracting, similarly rotating poles. In any other position they repel each other.

THE ZEEMAN EFFECT AND SWEDENBORG'S DOCTRINE OF ELEMENTARY MAGNETIC PARTICLES

Swedenborg declared that magnetism resides in the smallest particles of iron which are *always* least magnets, and he attributed this magnetic quality to an essential internal revolution, which elsewhere he identifies as a higher degree of "heat," or what we might call perpetual interior "thermal" (*i. e.*, revolutionary electronic) energy of atoms, incommunicable to other atoms. He also spoke of a higher degree of *light*, but did not explain himself. By analogy, we may infer that he was thinking of light as proceeding from these least revolving electronic, magnetic constituents of matter,—consisting of the minute vibrations which, as we know, produce the spectral lines, and *whose frequency can be changed by external magnetic forces*, constituting the Zeeman effect.

Professor J. H. Jeans ("The Mechanism of Radiation," Phil. Mag., (6) Vol. II, p. 421, 1901) says: "If an atom consists of n negative and $n + s$ positive ions, the total charge on the atom will be se, and may be referred to as the valency of the atom. . . . In a rotating atom or molecule we have the rotation of a system of charges of electricity. The net result is therefore equivalent to a circular current of electricity in the direction of rotation. Hence in the case of vibration the result is emission of electromagnetic waves; but the force on the molecule or atom varies in direction at each half-phase. In case of a complete rotation the current and forces are of constant direction; the atom or molecule may be regarded as a permanent magnet of moment proportional (except for irregularities) to the angular velocity, and of axis coinciding with the axis of rotation. In general the axes of these molecular magnets will be distributed at random, so that the solid will exhibit no magnetic properties. If the solid is placed in a magnetic field, there will be a couple on each such magnet, tending to turn its axis of rotation parallel to the lines of magnetic force."

The last part of this explanation is in substantial agreement with the theories of magnetism propounded by Swedenborg and Ampère. "In a rough piece of iron not yet rubbed by the magnet, . . . one verticle tends to the right, another to the left, and not one is connected harmoniously with another." After magnetization, "all the parts are in a rectilinear and parallel situation" (Swedenborg's *Principia,* Part 2, Chapter 1, Article 30.)

Although there is today a general tendency to adopt Franklin's theory of a single electric fluid, there certainly seems to be a difference in its mode of action in positive and negative states, requiring further hypotheses. J. W. Swan has investigated the "Stress and Other Effects Produced in Resin and in a Viscid Compound of Resin and Oil by Electrification" (Proc. Roy. Soc., London, Vol. LXII, p. 338, 1897). The result is a deeply impressed figure which can be shown by warming even after the lapse of a day. "The persistency and fixity of the electrification of the resin surface, determining the form and character of the eventual figure, are very remarkable." The positive impression (Fig. 8 from Swan's Pl. 1, Fig. 4) seen on the surface of the viscid liquid is star-shaped with "deeply furrowed, closely clustered, outward-branching rays, extending from a circular frill near the center to the margin of the liquid." The negative pattern (Fig. 9 from Swan's Pl. 4, Fig. 9) "is much smaller and weaker than the positive one; most frequently it consists of a circular, or nearly circular band, or ring, more or less indented in outline, enclosing leaf-like rays which tend towards the center. These are relatively broader and less branching than the rays of the positive figure, and they are characterized by having their outlines in relief, while the rays of the positive figure are sunk below the plane of the surface." These figures suggest that positive electrification is an outflow of the aura, extending radially around a center of electrification and producing attraction by modes similar to those of Bjerknes' pulsating drums; while the negative electron is the actual inward flow of a volume of aura in a self-contained vortical movement. If so, the negative electrons are so placed on the electrified surface as to have their indrawing poles presented outwardly.*

Free ions exist in the atmosphere, being produced in the upper air by the action of the sun's ultra-violet rays, and in other ways. It is probable that electrons, emitted either from the high-latitude prominence-zones of the sun, or from sun-spots of exceptional activity, proceed along magnetic lines of force in the vicinity of the Earth in great spiral sweeps until they enter our atmosphere in swarms, producing the flickering glow of the aurora by their impacts upon the molecules. The ions thus generated often serve as nuclei of aqueous condensation and the auroral streamers, at first clear cut, become involved in a luminous cirrus haze. (Compare my report of the very brilliant au-

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* In the positive rays, the aural circulation in the electrons opposes the motion of advance. These rays therefore move more slowly than the cathode rays, nor could they advance at all were they not carried by the electrified atoms.

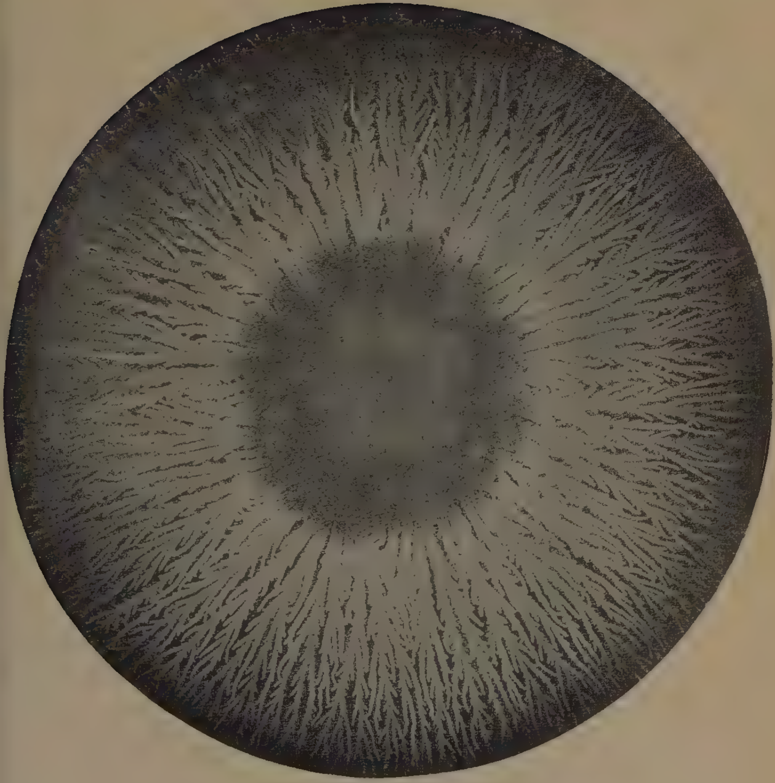

Figure 8.

rora of March 22, 1920; Monthly Weather Review for July, 1920, page 386.)

The ions may be strained out of the air mechanically by a wool filter, and also electrically. They rapidly diffuse out from a limited volume of air—the free negative electrons more rapidly than the positive ions in dry air (being smaller and are able to move in their own right, as just said), but with equal speed in moist air, apparently because the negative electrons become attached to neutral atoms and are then heavier negative *ions* which serve as nuclei on which water condenses, while the positive ions do not receive a proportional accession to their mass. The negative electrons have consequently an important function to perform in the production of rain, and the further study of radio-activity may be expected to throw light on the cause of rainy and dry periods. In fact, strong thunder storms as well as auroras accompany powerful solar disturbances. Though so small, the free electrons have thus a very real existence and importance for our lives; but their chief interest philosophically, is from the information they give in regard to the structure of matter. Their relatively free flow through solid wires as electric current confirms Swedenborg's prevision that the finer orders of particles can penetrate the grosser with but little hindrance. Thomson's discovery of these corpuscles and of their function as essential constituents of the atoms, has necessitated the restatement of wide fields of chemical and physical science; and it is of special interest to students of Swedenborg's philosophy, because it was predicted by his theory of the composition of elementary particles by the gathering together of many thousands of corpuscles which are so many aural vortices, themselves containing thousands of still smaller entities.

Since the atom is at any rate composed of entities with opposite properties and is subjected to the interaction of balanced forces of attraction and repulsion, the dual combination is obviously favorable to the production of oscillations of many kinds, which are appropriate or germane to the modes of motion of a dual (electromagnetic) ether with affinities for both matter and the aura, and material oscillations can readily be transferred to it as luminous vibrations of infinite variety.

The case is different with heat whose tendency is to flow and to produce uniformity. Whereas light can be transmitted at a given point in space from every possible direction, heat can only flow in one direction at a particular point. Carnelley's equation indicates that heat enters into the composition of an atom, not as a separable addition to other ingredients of coördinate value, but as a factor by which all the other quantities are to be multiplied. Van der Waals' equation indicates that heat must be considered cubically, and not as a two-dimensional quantity like the two electricities in their positive and negative alternations. The mathematical discoveries of Hicks in regard to vortex-aggregates and their applicability to the periodic variations in the fusibility of the elements, suggest that in the self-contained vortical flow of their internal aura resides the means by which quasi-thermal energy is distributed within elementary particles without being dissipated by its own tendency to indefinite expansion. It is obvious that the motions which constitute "thermal" flow within the atoms are not the vibrations which start the radiant waves in the ether; and yet the two processes are most intimately connected. If we imagine an oscillatory system of electrons, it seems to require connection with and to be encompassed by a fluid in steady rotary motion as in the composite vortex-aggregate of Hicks—a definite, so-to-speak, *thermal*

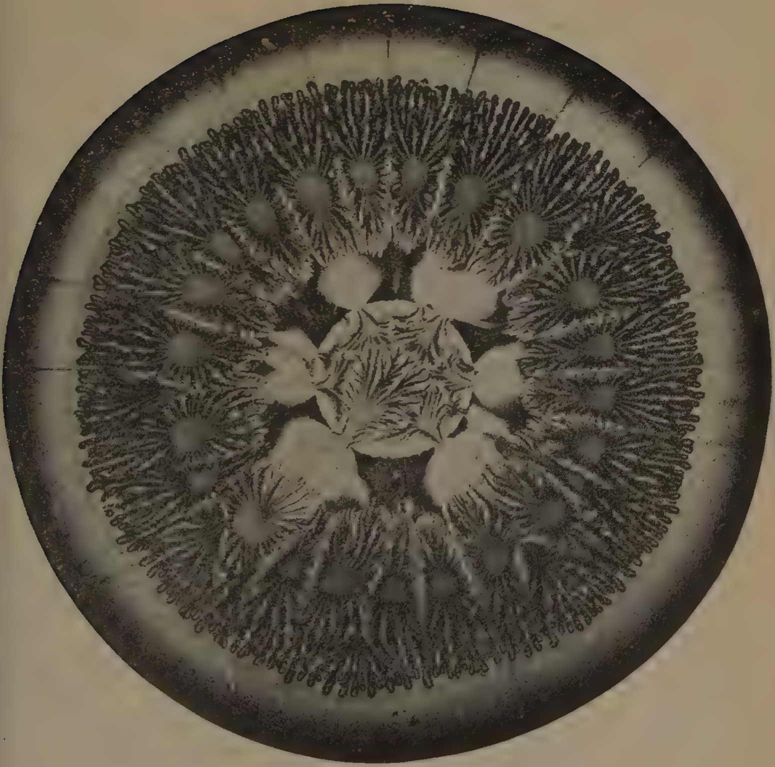

FIGURE 9.

atmosphere in which any increase in the energy is accompanied by enhanced flow and intensification of the oscillatory motion of the inclosed electrons, producing radiation, and occasionally rearrangement of parts.

A different suggestion has been given by Larmor (Proc. Roy. Soc., London, Vol. LXI, p. 272, 1897) in the representation of an atom as a collection of electrons describing stable orbits around a common center. The discussion of the internal vibrations of such an atom and the consequent radiation will follow the lines of Laplace's general analysis of the oscillations about steady motion of a group of connected bodies like the solar system. When the gyrations, or orbital motions, are sufficiently rapid, there will be two types of vibrations produced by disturbance of the system, namely, very rapid ones which radiate light, and very slow ones like the precession of a spinning top, which do not involve appreciable internal deformation of the system. In gases it is only these latter that would be excited sensibly by the comparatively gentle encounters between the molecules; these are in relation to thermal energy, but are only in indirect connection with radiation. However, in addition to being mechanically possible, a rational scheme of atomic structure must be capable of explaining such phenomena as the uniform recurrence of spectral sequences, the Zeeman effect, the difficult problem of the ratio of the two specific heats in gases and its variation, etc. The perturbations in such a system as Larmor's would seem, at first sight, to invite an indefinite succession of dissimilar variations, rather than a recurrence of special configurations; and consequently the existence of spectral series favors some oscillatory scheme. The theories of Larmor and of Thomson are not mutually exclusive, however, and it is probable that both oscillations and revolutions of the electrons are combined in the complex movements within the atom. In fact, such phenomena are assumed in the atomic theories of Parson and Langmuir.*

If a corpuscle is actuated by forces tending to produce equal and opposite orbital revolutions, the resultant is a linear vibration, since.

$x = r \sin \theta$, $y = r \cos \theta$, added to
$x = r \sin \theta$, $y = -r \cos \theta$, gives
$x = r \sin \theta$, $y = 0$.

If one of the rotary accelerations is of greater amplitude than the other, its period remaining the same, an elliptical revolution results. Calling a and b the semimajor and semiminor axes of the ellipse, an elliptical vibration,

$$x = a \sin \theta,\ y = b \cos \theta,$$

is equivalent to the sum of two opposite circular vibrations:

$$x = \tfrac{1}{2}(a + b) \sin \theta,\ y = \tfrac{1}{2}(a + b) \cos \theta,$$
$$x = \tfrac{1}{2}(a - b) \sin \theta,\ y = -\tfrac{1}{2}(a - b) \cos \theta.$$

Now if a line of magnetic force passes through such a system, it exerts a force tending to place the plane of revolution at right angles to the line of force and the ethereal rotation around the line of force necessarily accelerates one compound of the corpuscular revolution and retards the other, and this by equal amounts. Hence the movement which previously generated a homogeneous ether-wave of a definite length, becomes separated into two parts by the magnetic action. One part has its period lengthened, the other part has it shortened by an equal amount. If the light is viewed by a spectroscope pointed along the direction of the line of magnetic force, two spectral lines are seen where only one was present originally, and the light corresponding to one of the two is circularly polarized with a left-handed rotation, the other is circularly polarized with right-handed, or clockwise rotation. The relation between these rotations and the positive direction of the magnetic field, is such that the moving electric particles are supposed to have the negative sign. If so, the particles which move within the atoms, and which produce the spectral lines, must be identical with the negative electrons which make the cathode rays. However difficult it may be to isolate single free positive electrons, there is every reason to believe that they exist within the atom with numbers, masses and electric charges sensibly the same as those of the negative electrons. Zeeman gave as the result of his magnetic experiments, "that $e : m$ [the ratio of charge to mass for one of the radiating particles] is of the order of magnitude 10^7 electromagnetic C. G. S. units" (Astrophysical Journal, Vol. V, p. 343, May, 1897). Rutherford, in his "Radio-activity" (2d Ed., p. 77), citing this measurement, says: "The charged ion, responsible for the radiation from a luminous body, is thus identical with the electron set free in a vacuum-tube," *i. e.*, with the negative electron. This is correct as to magnitude, but as to the electric sign, Zeeman declared repeatedly that his particles behaved like "*positive* ions." He says of his revolving ions: "If revolving in the positive direction (viz., in the direction of the hands of a watch for an observer standing at the side towards which the lines of force are running) the period is somewhat less than if revolving in the negative direction." (*Op. cit.,* Art. 18, p. 340); and on page 343 he cites this as showing "that the positive ions revolve." Professor J. J. Thomson in his "Elements of Electricity and Magnetism" (3d Edition, p. 192) defines "positive magnetism" as "concentrated at the end which points to the north." If Zeeman's lines of magnetic force were running towards the observer, as stated, that is, with the positive or north-seeking magnetic pole facing the observer, the *negative* electrons will be the ones to revolve clockwise and be magnetically accelerated, or to have their periods shortened.

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* Since Langmuir's "sheath" is considered to be composed, when complete, of an octet of negative electrons, we may presume that the underlying pair of electronic shells has the one consisting of positive electrons outermost, since otherwise the negative octet would not be retained but would be immediately repelled and lost.

If all atoms have their boundaries in spherical shells of positive electrons, these shells cannot be brought into immediate contact on account of the great repulsion developed on a near approach. Yet at a certain distance determined by this repulsion, perhaps combined with the electric resistance of an ethereal atomic "atmosphere," the repulsive forces are precisely neutralized by the magnetic attraction of pairs of magnetons, as described in the latter part of this section. Various theorists have recognized that attraction and repulsion in alternation are exhibited in the relation between particles as a function of distance.

As I have proposed the hypothesis that there is only one electron which may be either positive or negative according to its presentation, I should naturally be very glad to find some authentic confirmation of my position. But it seems to me that in this case Rutherford is right and that Zeeman's electron was a *negative* electron, in spite of his contrary statement; and the inference is that a *free* electron always behaves as if it were negative and only acquires positive qualities by its pose when in association with a group which constitutes a positive ion or a positive nucleus. Consequently, free positive electrons can not exist.

Actually, the motions of the electrons in the Zeeman effect are not always as simple as those just described, but still they can be resolved into a system of linear vibrations parallel to the lines of force, combined with left-handed and right-handed circular motions in a plane at right angles to the lines of magnetic force. Hence when the light is viewed athwart the lines of magnetic force, the orbital movements which have been brought into the normal plane by the magnetic field, will be viewed in section as plane-polarized vibrations, transverse to the direction of the field. The linear components of the vibration, lying parallel to the lines of force, generate ether-vortices alternately with and against the magnetic rotation, and continue as linear vibrations parallel to the field, but alternately accelerated and retarded by equal amounts, the separation of the corresponding spectral lines being usually half as great as that of the other pair, although in some iron lines it appears to be the greater.

If the original vibration is an elliptical one, the disturbing magnetic force rotates the ellipse in its own plane, and also oscillates the plane, producing various complex patterns. "The intensity of outer groups may accordingly appear as single or double or triple or multiple lines." (Michelson.)

Here we see a great variety of possible motions within the atoms, and motions which originate light. These motions can, in turn, be restored or augumented by the absorption of light in the atomic structures. Swedenborg's assertion that light "modifies substances as to their least parts" is abundantly confirmed; but what an immense body of science flows from this simple statement! It resembles Newton's concise "law of gravitation" in which lies concealed the whole of celestial mechanics.

To sum up the results of our comparison of Swedenborg's theories with the facts of chemistry, we find much evidence favoring the existence of a form of vortex-motion within the atoms, or rather of more than one form. There is the motion of the aura *within* the electrons which seems to approach most nearly to Swedenborg's specification.

Next the atom itself exhibits two distinct classes of thermal phenomena:—First, there is a progressive disappearance of thermal energy as the atom becomes more complex, which thermal energy is restored when the complex atom breaks up in radio-active transformations. This interior and ordinarily imperceptible "thermal" energy is heat of a new sort. It seems permissible to identify it with Swedenborg's "second degree of heat." Energy is used up, that is, disappears or becomes latent, in generating the orbital revolutions of thousands of mass-giving electrons within the atom. The progressive increase of this property keeps pace somewhat closely with the increase in the numbers of the included electrons, or with the atomic weight.

Second, there is a periodic appearance and disappearance of an internal energy on which the "atomic heat" and the "atomic volume" depend. This, in all probability, is consequent upon the successive addition of paired shells of mass-giving electrons, whose dual component members revolve in opposite directions. Such revolutions would seem to require some sort of opposing motions in the circumfluent and attendant aura. The theory of Hicks concerning compound vortex-aggregates, supplies a hypothetical form of motion which requires just such properties of alternation. This form of vortex-motion has some analogies with Swedenborg's conception, but is more complicated. Instead of the rather crude limitation of the vortex by a superficial layer of passive or finiting particles, Hicks presents the conception of a virtually limiting surface where vortex and stream-lines interchange, and where the direction of revolution reverses. It is true that these are interior transition-surfaces, and that the theory does not provide for any external limiting surface. Externally, the atom, if this were all, would simply fade away gradually to the general aural movement. But this cannot be the hole story. Yet considered as a part, and an important art, of the paraphernalia of atomic constitution, is not uch an indefiniteness of the atomic boundary something be anticipated? Consider how difficult it is to assign a efinite outer limit to the earth's atmosphere. Nowhere in ature is there absolute independence. Everywhere there re interrelations and graduated transitions.

Swedenborg's superficial finiting particles may have an nalogue in the outermost shell of revolving electrons in e atom, but, if so, they are not associated together in e way that he supposed, since they are not in contact, but re held together by the electromagnetic field which resides the aura.

The energy of this complex of electronic orbital revolu- ons and attendant aural vortical motion, or rather the ergy of the interpenetrating aural stream whose motion alone distinctly of the vortical character, but which can ot be separated from the complex, furnishes a basis for, an embodiment of Swedenborg's conception of a third, most "degree of heat," although it would be more nearly accordance with general analogies to restrict this term the essential vortical motion of the least particles of the ra itself, which may indeed be regarded as fundamental rticles of energy, even as we speak of the electrons as rticles of electricity.

ATOMIC STRUCTURE

We have seen that Swedenborg thought that matter is mposed of particles of several orders of magnitude, all vigorous internal motion, and that, at bottom, it is noth- g but energy. How far is this conception confirmed by at we now know? I believe that it is wholly confirmed as a broad general statement, though naturally many of the details have been modified by the progress of science. We find a wonderful complexity in the intricate motions within the atoms.

In addition to this, Swedenborg taught that two different sorts of entities are combined in all elementary structures, namely, actives and finites. Actives alone "finite nothing," he says. This also is true as a general, rather vague, statement, but many new things have been discovered in regard to modes which were not included in the prevision. We find the atoms composed of electrons whose orderly arrangement "finites" the structure, but it is the active forces between the electrons which interiorly control the functioning of the several parts, enabling them to act as a unit.

Since the conception of atomic structure presented here is unfamiliar, at the risk of incurring criticism for repetition, I will once more gather together the evidence which seems to be demanded in order to reconcile opposing views.*

The spectroscope has given us our first aid in unraveling the structure of the atom. The spectrum of hydrogen, consisting of a series of bright colored lines, continued into the ultra-violet, and arranged in a sequence of harmonically related frequencies, yielded to Balmer an empirical formula which fits the facts very well. Its meaning has been explained by Bohr as follows: Each hydrogen atom is supposed to be attended by a single negative electron revolving around a positive nucleus in a circular orbit. If this electron is displaced, it does not return to its first position gradually, as if it were sliding down an inclined plane, or exhibiting an even spiral motion of gradually diminishing radius, but moves suddenly from one circular orbit to another by a series of steps, lingering, we may suppose, for a very brief interval in any given orbit and then giving up a single least quantity of radiant energy, at the same time falling to the next stable orbit. Each step represents the momentaneous origination of one spectral line.

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* The treatment of the subject in what follows is substantially that given in my paper read before the American Astronomical ociety in 1921 which has already been cited, but appears in its "Publications" only in abstract.

The process being continued from atom to atom, the sum of the electronic kinetic energy of revolution and rotation transformed into the specific radiation at each step in one second is proportional to $h\nu$, where h is Planck's unit of energy and ν is the frequency. The application of a modified Keplerian equation for revolution under a central force accounts for the phenomenon with an accuracy which seems little short of marvelous. However, a slight discrepancy in respect to the computed amount of voltage required in the electrical transformation has led Langmuir to propose a modification of the plan. His argument favors the proposition that the hydrogen molecule has two attendant electrons which oscillate in one plane, but in opposite directions at any given moment, through arcs of eccentric circles, and are mutually repelled on reaching the extremities of the arcs. Monatomic helium is equally provided with a pair of electrons which oscillate through eccentric arcs of 77° 58′ on either side of their mean positions.

Founding his conception on a model suggested by Landé and assuming that the angular momentum of an electron is $h/2\pi$ and is magnetically transferable to other electrons, Langmuir concludes that the repulsive force between oscillating electrons can be substituted for the centrifugal force of Bohr's revolving electrons, and that "the Rydberg constant, the Balmer series and all the other series calculated by Bohr can be obtained by this method without assuming electrons moving about the nucleus," that is, moving in definite orbits.* It is possible that this oscillating form in paired electrons is the normal one for *molecular* hydrogen. The electric argument confirms the supposition for helium. But Bohr's explanation of the Balmer series in hydrogen is not overthrown, because this appertains to the freely vibrating hydrogen atoms in ionized gas, such as is observed under the conditions of the vacuum-tube spectrum and of the solar atmosphere where the molecules are dissociated.

Langmuir does not extend his hypothesis to associations of more than two electrons; but Bohr's hypothesis, supplemented by the reasonable supposition that the mechanism of the production of radiation is simply a gyrostatic reversal of rotating electrons revolving in orbits and that such reversals do not take place in normal steady revolution, is applicable to complex groups.

Bohr's hypothesis does, indeed, violate Sir J. J. Thomson's assertion from electrical theory, that a *single* revolving electron is unstable; but since its existence appears to be established, the adverse theory must be incomplete and requires modification.

To the astronomer it is decidedly interesting to find that Kepler's laws, which were established from observations of the planetary revolutions, apply with very little change to these least revolutions of the little things of nature. A slight change, however, must needs be made, because the revolution of an electron can not take place without producing a magnetic effect, in addition to the electric attraction; but the revolutions of the planets do not generate magnetism and the law is therefore simpler.

The "astronomical atom" satisfies the spectroscopic evidence of recurrent motion. Here then we have very cogent testimony in favor of electronic revolution within the atom. But on the other hand, Gilbert N. Lewis, A. L. Parson, and Irving Langmuir have independently adduced *chemical* reasons, slightly different as to modes of explanation but all agreeing on one point, namely, that there are certain very significant electrons within the atom which do not revolve about a common center, but maintain relatively fixed positions in respect to each other. The number of these fixed electrons is supposed by Langmuir to be equal to the Moseley number; but so is the number of revolving electrons in Bohr's theory. Hence arises a dilemma: The chemists say that these electrons are relatively fixed. The physicists say that they revolve. The obvious solution of the dilemma seems to be that there are *two* sets of electrons, each of them equal in number to the Moseley number, one of which revolves, while the other stands still.

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* The original suggestion will be found in an article by Dr. Irving Langmuir in Science for June 18, 1920. The quotation is from a second article in Science for March 25, 1911, page 291.

"Since the electrons must occur in pairs symmetrical to the equatorial plane there are no electrons in this plane." (Langmuir, "The Arrangement of Electrons in Atoms and Molecules," Postulate I.) These electrons may be called the "chemists electrons" and form the first set; but the "physicist's electrons," or those of Vegard's rings, are *all of them in the equatorial plane.* The two chemist's electrons of helium have polar positions according to Langmuir: "This same pair exists (as Shell I) in the atoms of all the other inert gases and determines the position of the polar axis." (*Op. cit.*, p. 872.) An oscillatory pair or possibly a revolving trine of electrons giving the X-ray radiations of the K-series is constantly present in every atom except hydrogen. This pair (trine?) probably belongs with the physicist's electrons, or is additional to Langmuir's polar pair, and hence oscillates in the equatorial plane.

Even this, however, does not tell the whole story.

Langmuir finds that the chemical properties of a neutral atom depend on the number of electrons in an external layer which he calls "the sheath." But in addition to this sheath the heavier atoms have other layers of internal electrons (the internal layers and positive nucleus constituting the "kernel"), so that, if all of the layers contained their full quota of electrons, we should find that, beginning with helium with two electrons, six successive layers are called for, in order to complete the scheme, with 2, 8, 8, 18, 18, and 32 members respectively. Any further additions form the beginning of yet another incomplete layer.

Now while excellent reasons are given for believing that there must be these supernumerary electrons arranged in layers, no reason has been given why they should be thus arranged, except the one which I have put forth which calls for a succession of chambers within the atom, formed by somewhat regularly spaced spherical shells of revolving electrons, each shell being double and consisting of quantitatively equivalent members, the one set of positive, the other of negative electrons. These aggregations of mass-giving electrons are necessary to account for the atomic volumes of the elements. Their neglect in current chemical theory is most extraordinary and leads to such absurd statements as the following: "The volume occupied by the sodium ion in sodium fluoride is 7.6. The free electron in metallic sodium increases this to 23.7 so that the electron seems to require a volume of 16.1, or *more than twice that of the octet.*" (Langmuir, *op. cit.*, p. 912, italics are mine.) In other words the electron is here given a volume more than twice that of the external sheath of an atom (!). But we have seen that the diameter of an electron is undoubtedly *less* than that of an atom, probably in some such ratio as 1 : 100,000. Equally incomprehensible is the current scientific doctrine that the nucleus of an atom is very much smaller than an electron, yet that out of it can come full fledged atoms of hydrogen and helium (!).

Maxwell says: "We must assume that in every electrolyte each molecule of the cation, as it is liberated at the cathode, communicates to the cathode a charge of positive electricity the amount of which is the same for every molecule, not only of that cation but of all other cations. In the same way each molecule of the anion when liberated, communicates to the anode a charge of negative electricity, the numerical magnitude of which is the same as that of the positive charge due to a molecule of a cation, but with the sign reversed." (Electricity and Magnetism, Art. 259.)

The precise equality of the elementary positive and negative charges (only the sign being reversed) which is noted in this passage, is very ill explained by the hypothesis of a positive proton of excessively minute size at the heart of each atom, surrounded by much larger electrons; but my hypothesis that there is only one electron, dual only by virue of its polarity, is distinctly suggested by the same equality.

The stress figures around a negatively electrified sphere seem to imply an outward motion of a vorticose character. If the negative electrons are attached to the surface of the sphere, we should have to suppose that they have outflowing poles which produce outward movements in the surroundng magnetic aura. But if the outflow is that of the elecrons themselves, we must presume that they advance by drawing-in the surrounding medium and that the negative electrons present their indrawing poles outwardly. This appears to be the case and therefore negative electrons are more readily movable. Let us then assume that the electron moves in the direction of its indrawing pole and that equal electronic streams which move in opposite directions have the relation of equal positive and negative currents and are both electrically and magnetically neutral.

The discovery of light-quanta of absolutely uniform dimensions* has demonstrated the fact that light is corpuscular, even as electricity is composed of corpuscles. And the further fact of dielectric polarization in connection with optical phenomena points to the polar structure of the electrons from which light originates, which is best explained by supposing that the electrons are nearly spherical vortices in the universal magnetic aura, on atmosphere of space.†

The atomic scheme is founded on a mathematical conception proposed by Hicks, but is here given concrete form in a way which fits in very well with the complex requirements of the assembled data. In the vacant spaces between the paired shells there is room for both fixed and revolving supernumeraries, and there is also a reason why they should have these special positions. The special revolving electrons which give X-rays are supposed by Dr. Vegard to be arranged in interior *equatorial* groups, so spaced and so speeded as to give the different sorts of X-ray spectra. The fixed electrons of Langmuir's "octets" * may be presumed to find their positions of greatest stability in latitude 45° of the spherical atom, being normally kept there by their mutual repulsion. If we could suppose that the fixed and revolving electrons are respectively positive and negative, or else that the fixed electrons are magnetic and are retained in the magnetic field of the revolving ones, reason might appear why the two groups should be equal in number, though different in function; and at any rate it seems more reasonable to suppose that the supernumeraries should be nearly proportional to the atomic weights, than that they should have the ratio of the half weights.

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* This statement requires further explanation. It is the energy-constant (h) which is invariable. This must be multiplied by the frequency (ν) to give the light-quantum. A hydrogen satellite electron which has received a sufficiently powerful shock to displace it to the fourth stable orbit, returns by a succession of steps from the fourth to the first orbit, giving out the spectral lines. H_δ. H_γ H_β and H_α, with diminishing frequencies. The energy required to throw the electron to an outer orbit is greater than for an inner orbit in the ratio of the frequencies of the two. To get the total energy we must sum the number of etherions in unit-volume of radiation, each etherion, or oscillating light-corpuscle, representing a single electronic reversal. The higher orders of lines in the Balmer series of hydrogen require so much energy for their production, that they are only found in the spectra of the hottest stars.

† As shown in my paper, "The Luminiferous Ether," pages 15 and 35.

The successive tiers of concentric matched shells, taken by themselves, will exactly give a series of absolutely neutral atoms, without either chemical or electrical properties. How then can we become aware of their existence?

The answer is, that (1) the existence of these electrons (the "mass-giving electrons") is made known to us by the chemist's balance, and is the chief source of that property of atomic weight which is so fundamental for chemistry.†

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* From X-ray spectrum examinations Bragg demonstrates that each atom in a solid occupies a unit-cube of definite size, doubtless determined by the position of the Langmuir octet. But within the cube must be the aforesaid revolving spheres.

† The atomic volume of hydrogen is 57% greater than a simple proportion to the volume of the helium atom would give on the assumption that four atoms of hydrogen unite to form one helium atom with no change of volume. We may infer that the free hydrogen atom is expanded by the centrifugal force of its internal electronic revolutions. And since the weight of a hydrogen atom is greater by 0.8% than a precise 1 : 4 ratio of weights might lead us to expect, it is probable that the more rapid internal motion, besides expanding the free hydrogen atom, has slightly increased the mass of its electrons. Certain other deviations of the atomic weights from precise multiples of the weight of the hydrogen atom are now known to be the results of the mixture of isotopes; but possibly other small deviations may be traced to increase of electronic mass from exceptional internal velocities.

The supernumeraries add a trifle to the atomic weight, but are relatively insignificant in this respect, even though they may be the most important electrons in some other ways.

(2) The existence of some such structure within the atom is distinctly called for by the thermal properties of the atoms which recur in a succession of waves exhibited in Lothar Meyer's curve (with which W. L. Bragg's curve of the atomic diameters, determined by X-ray examination, has a strong resemblance at any rate as respects the rise and fall in successive waves.) These waves are explained if we concede that the increasing condensation of a series of atoms of successive species, as the mass of the individual atom increases, is interrupted at intervals by the accession of new pairs of electronic spherical shells at certain nodal points, with expansion of the atomic volume at these points. As new shells are added to the evolving atoms, the innermost shells become condensed and their angular velocities, together with the angular velocities of Vegard's rings,* are increased, so that the frequencies of their characteristic X-rays become more rapid.

(3) The hypothesis fits in very well with the fact that dense gases, as well as solids, emit light, when heated, which gives a continuous spectrum; for if the collisions between the atoms of the gas are sufficiently numerous and powerful, the orbits of the electrons in the spherical shells may be either condensed or driven polewards, in either case immediately returning and oscillating about a mean position, but with variation in the time of revolution, since the circular motion has been turned into a spiral one which gives progressively varying periodicities of considerable range.

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* Compare Dr. Vegard's Fig. 1 and Table VII in the London, Edinburg and Dublin Philosophical Magazine for April, 1918, page 317.

The more vigorous the impacts are, the more condensed will be the electronic orbits and the more rapid will be their periods. Consequently, heat extends the continuous spectrum to shorter wave-lengths.

(4) If there are indeed in the atom tens of thousands of revolving electrons arranged in circular strands on the surfaces of spherical shells, we should anticipate that, while a thermal shock of sufficient power will set them all spirally oscillating in a common motion (but with varying angular velocities) and will thus produce a continuous spectrum, it may also be possible to set each individual electron oscillating independently and monochromatically through electrical means. Now this is exactly what takes place when, for example, a mass of iodine vapor is illuminated by the strong green mercury line ($\lambda = 5460.74$ A) when, as Professor Wood discovered, there immediately arises an exceedingly complicated iodine resonance spectrum, containing something like 50,000 lines between wave-lengths 0.5 and 0.8 μ. These lines are arranged in groups which, I take it, represent the vibrations appertaining to the electrons of as many successive strands in a particular electronic shell,* while each line comports to the motion of an individual electron as it is inductively modified by the variation of its neighbors. To express the law of this complex induction mathematically will be very difficult, but the problem is now visualized.

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* A certain amount of freedom is required for this electronic individual oscillation, because when the iodine vapor is ionized, or reduced to single atoms, these, as is also the case with monatomic helium at elevated temperatures, are so hammered in their numerous collisions that they become compressed and the line resonance ceases. Diatomic molecules are not thus compressed but are simply set into oscillation about their common center of gravity by thermal shocks.

Returning to the fixed supernumerary electrons, Parson* assumes that the Moseley number of an atom should be increased by six to allow for as many elements to be introduced between hydrogen and helium. This would give to iron the atomic number 32, instead of Moseley's 26. But the hypothesis is not tenable. Professor Hull's remarkable analysis of the diffraction spectra of an iron crystal by means of the X-ray,† demonstrates that the atomic number of iron is 26. Where then shall we place the new lighter elements—coronium, nebulium, protofluorine, etc.? Nicholson's computations‡ supply an answer, for whereas the perturbation of a single revolving hydrogen electron demands the exhibition of a single quantum of energy (6.56×10^{-27} C. G. S. units), Nicholson finds that nebulium behaves as if it had a ring of four electrons (which would give a Moseley number the same as for beryllium) and protofluorine as if it had a ring of five electrons with the same Moseley number as boron, when, nevertheless, each ring requires only one quantum of energy for its displacement from one stable orbit to the next, so that here, by exception, each individual electron in the ring demands only its fraction of the energy-quantum, and all of these elements have the same valency as hydrogen.§

This suggests that possibly there is something similar in

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* A. L. Parson, "A Magnetic Theory of the Structure of the Atom." Smithsonian Miscellaneous Collections, Vol. 65, No. 11, (80 pages) 1915.

† A. W. Hull, "The Crystal Structure of Iron." Physical Review, Ser. 2, Vol. IX, p. 84, 1917.

‡ J. W. Nicholson in several papers in Monthly Notices R. A. S., Vol. 72 (1911-1912).

§ This is not the only hypothesis which has been proposed concerning these extra terrestrial elements. Unless they should be discovered on this earth, so that we can experiment with them, this part of our subject, though of the greatest interest, must remain a speculation.

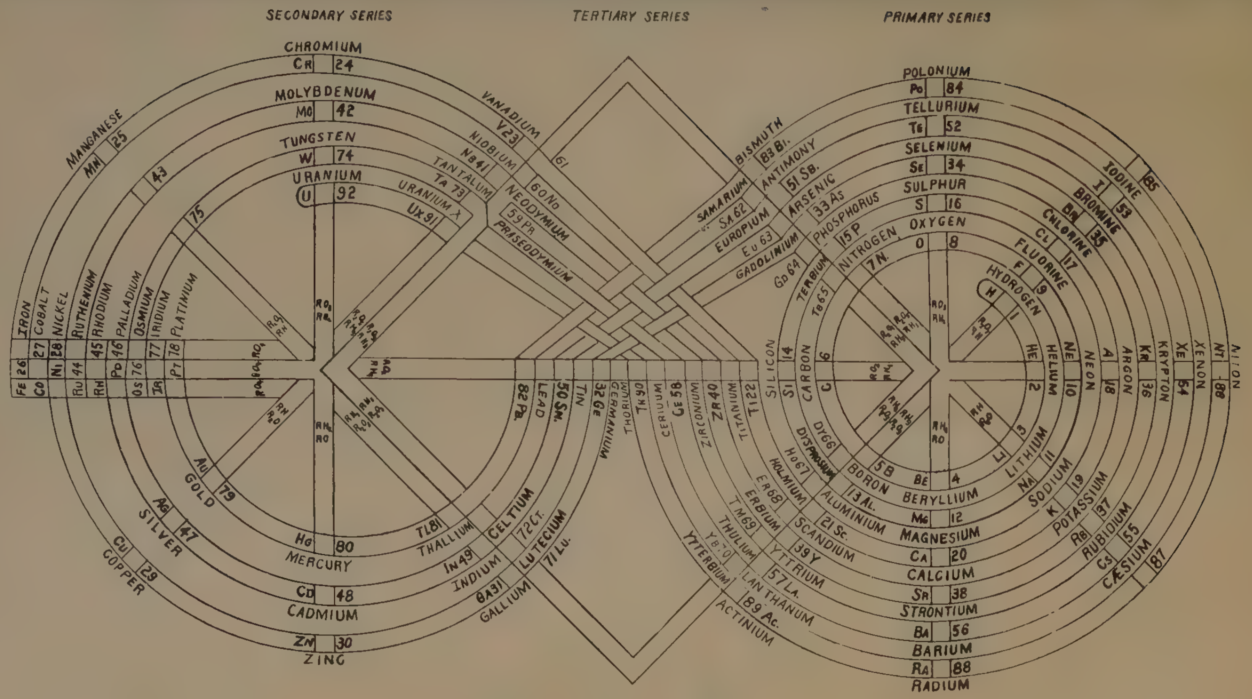

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FIGURE 10.

he constitution of the metals of the rare earths. Mr. W. W. Carter has shown that the position of the elements in he Mendeléeff classification may be represented by two spirals (Fig. 10), if there be diagonal interlacing connections representing the elements of the rare earths, which n this case occupy a very peculiar position. The other elements (with the exception of the aforesaid coronium, nebulium series) have their normal valency assigned by the ntersectings of their Moseley-numbered positions on the spirals with eight radii, 45° apart. But the metals of the rare earths all have the *same* valency, namely, three. They do not fall on the spirals. It seems possible that here, by exception as in the lighter elements between hydrogen and helium, these rare earths possess, say, arrangements of certain electrons in three rings, where each ring or magneton functions as if it it were a single electron and requires but a single energy-quantum for its displacement. This would explain the common valency in spite of the considerable range in the Moseley numbers. I shall show presently that the valent electrons probably have the ring-form, whether several electrons or only one electron appear on the ring (let it be noted that the vortex structure of an electron renders such a structure quite feasible.) The problem is one to be decided by the investigators of X-ray spectra.

One other phenomenon connected with the puzzling rare earths may mean that they have such electronic rings or magnetons, to which their magnetic properties are due, and that these are near the outside of the atom, namely, this: By exception, certain of the rare earths when *thermally* excited in the *solid* state, give out a line spectrum superimposed on a continuous spectrum. It looks as if certain electrons were relatively free to vibrate in their own individual manner even in the solid material.

In case evidence should be forthcoming which forbids the supposition that the revolving and stationary electrons have opposite electric charges, that is, if it can be conclusively shown that both sorts are negative electrons, then it would appear that there must be yet another group of positive electrons equivalent in charge to the total negative charge of the revolving and stationary supernumeraries. This extra positive charge may be due to an excess of positive electrons in the paired spherical shells of mass-giving electrons, or the positive charge may be concentrated in a central nucleolus of the entire system. The latter would be more in consonance with the astronomical analogies of the solar system, but the former with those of the spherical star clusters. In any case, by far the larger part of the electrons forming the complex group which we call the atom, go to form a completely neutral mass whose gravitational attraction is so small compared with the electric (or possibly to some extent magnetic) attraction of a small excess or deficiency in the supernumeraries as to be comparatively negligible.* This is the explanation of the slight influence which mass-action has on chemical change, for it is evident that chemical affinity is either an electric or a magnetic attraction, and in no case a gravitational one.

The following argument seems to decide in favor of the magnetic origin of chemical affinity: Professor Hull says of his observation of the X-ray spectra of an iron crystal (*Op. cit.*, p. 86): "We are forced, I think, to look for the explanation in the internal structure of the atom. . . . If all the electrons are displaced from the center of the atom along the cube diagonals in four groups of 2, 8, 8, 8, at distances 1-32, 1-16, 1-8 and 1-4 respectively* of the distance to the nearest atom, all the observed facts are accounted for within the limits of experimental error." But if all of the electrons are of like sign, their mutual repulsion would swing the diagonals of alternate cubes into planes 45° apart, whereas the cubes are concentric and their diagonals coincide. On the other hand, if these electrons are revolving in tiny orbits, each of them becomes a little magnet, and the planes of the orbits tend to set in parallelism with their centers of revolution in a single line as is observed. A negative electron revolving clockwise, as viewed from outside the atom, will constitute a north-seeking pole, and counter-clockwise revolution will give a south-seeking pole.† The positive and negative signs of the electrochemical formulae can equally well be interpreted either as positive and negative electricity, or as positive and negative magnetism.

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* As is shown in my paper, "Tourbillons Galactiques et Atomiques" in Bulletin Astronomique (Tome I, Fasc. II).

The sum of the stationary and revolving electrons, or twice the Moseley number, is approximately proportional to the atomic weight. A reason for the dual division into two groups has already been suggested. But there is another duality whose reason on the electrical hypothesis is not so obvious, namely: Langmuir's "covalent" electrons go in pairs. Why can not a single electron be shared by two atoms and give a stable diatomic molecule? Why must the chemical bond of stable union be a *pair* of electrons? Perhaps the answer is contained in the suggestion that covalency consists in the turning of two orbital electronic planes into parallelism with like revolutions and magnetic attractions, so that the two constitute one magnet with two poles. Where H + unites with H —, a single electron forms the connecting link and the bond is an electrostatic attraction. This molecule has been found by J. J. Thomson in his examination of positive rays, but is exceptional.

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* Langmuir's theory assumes radii in the ratio 1 : 2 : 3 : 4 (Postulate 2) and in this minor detail is not confirmed by the X-ray examination.

† It is probable that the electron is a nearly spherical vortex and that it progresses by its indrawing pole. Clockwise and counterclockwise electronic revolutions are, respectively, positive and negative electric currents with electrostatic attraction, but with a lesser electrodynamic repulsion, the latter increasing with the velocity until the speed of light is attained, when the thing goes to pieces in the radio-active elements.

The atom contains both spherical and angular arrangements, and similar forms recur farther along in the series; for crystallization begins with the segregation of material into spherical, solid particles, or globulites. These then arrange themselves in rows, passing into margarites, trichites, and dendritic forms which branch at definite angles and constitute a scaffolding or framework for the final angular crystals.

In the union of sodium and chlorine to form cubical crystals of common salt, the powerful attraction of the chlorine atoms pulls the sodium atoms from normal into diagonal piling with a certain amount of contraction thereby, because diagonal piling takes up less space than normal, and also because the chlorine atoms are the smaller of the two and can fit into the smaller interstices with a saving of room for the sum of the diverse ingredients. But this alone does not account for the whole of the contraction in the production of halite. The pressure exerted by the force of chemical affinity condenses the atoms themselves slightly. The revolutions of the mass-giving electrons in the spherical atomic shells are forced into smaller orbits by the pressure, and this evolves a large amount of heat proportionally to the orbital change. For heat, as I have shown, is peculiarly connected with the internal revolutions of the spherical atomic shells, meaning here by "heat" the inner energy of atomic formation. This latent heat of atomic formation is drawn upon to a slight extent when different atoms combine in order to give the atomic thermal reactions. Usually combination of atoms produces molecular contraction and evolution of heat; but there are a few endothermic transformations in which heat seemingly disappears and where presumably the internal atomic arrangement within the molecules is such as to give greater freedom of motion and expansion.

In the preceding example we have assumed that the atoms are spheres in contact. But the contact can not be absolute, for at very minute distances their surfaces repel each other. In the new theory of chemical affinity the attraction of the atoms is that of covalent electrons attached as appendages to the spherical atoms. Viewed as to this open-work net, the atoms are cubes, but the octet of valent electrons requires the underlying sphere to give it a stable basis. In the case of the carbon atom the net is supposed to have the form of a tetrahedron. These geometrical considerations require that the atoms in an aggregate shall be piled not merely with reference to the volume which they must fill, but also with reference to a special geometrical orientation of the superficial net. Thus neither Swedenborg's piling nor the Bravais space-lattice will give a complete specification of the molecular complex. The new X-ray examination of crystals unveils an inner structure far more complicated than external form alone would lead us to anticipate. Sir W. L. Bragg says:

> We know that it is possible to separate crystals into thirty-two classes, according to the kind of external symmetry which

they display. As we have hitherto been unable to look into the interior of the crystal, we have been obliged to be content with the imperfect classification by outer appearance. It has been shown, however, that there is a classification by inner arrangement which is perfect and includes the other. It is beyond the limits of ordinary vision; out of the range of the lens and the goniometer. The interior arrangements of the crystal, of which the outer form is one consequence, are so varied as to furnish 230 different modes. With very few exceptions the X-rays now allow us to carry the classification to this higher degree. If the modes are grouped according to the external features of the crystals that follow them, we come to the well-known thirty-two classes, there being several modes in every class." (Address before the British Association for the Advancement of Science at its Toronto meeting in 1924. Science, August 15, 1924, page 141.)

The address from which this citation is taken is an admirable explanation of the X-ray analysis of crystals, though necessarily very condensed. Swedenborg's incomplete conception of piling and of internal arrangement of particles in structural planes, determining the external shapes of crystals, is confirmed in a general way, but its details require modification. The hypothesis that the atoms are spheres must be slightly emended by the addition of the outer sheath, or enclosing network of the octet. All other figures of hypothetical atoms must be absolutely abandoned.

The argument for internal spherical shells in the atom rest on quite other grounds. When Langley invented the spectrobolometer, the way was opened for the study of the spectra of invisible radiations from heated bodies with a greatly enhanced precision. One of the results of our study was the discovery that the maximum in a spectral energy-curve moved towards the shorter wave-lengths as the temperature rose.* Further improvements in the delicacy of the apparatus and the experiments of Paschen and others, together with the mathematical studies of Wien and Planck, led to the determination of the equation representing this movement of the spectral energy. For ordinary radiation this is succinctly given by Paschen's rule, λ max. $\times$ T $=$ 2940, which states that the wave-length of the maximum radiation in microns, multiplied by the absolute temperature in Centigrade degrees, is equal to a constant (approximately, 2940.) That the law of energy (on which temperature depends) includes a constant factor was a little surprising, but it probably results from the further fact that there is within the atom an unceasing orbital revolution of electrons with constant velocity. If the dimensions of these orbits can be diminished (and under the more numerous or more powerful impacts of thermal vibrations at higher temperatures, we may suppose that this greater compactness of the orbits ensues) the orbital velocity remaining unchanged, the frequency of the period of revolution increases and likewise the frequency of any radiation which may be emitted in consequence of the thermal agitation. The continuous spectrum includes a wide range of frequencies and denotes the agitation of a great horde of particles which are not free, but must all move together according to a common law. Line spectra are due to the agitation of free individual electrons, whose freedom is guarded by the revolving shells. It is these free electrons which give the electric and chemical properties to the atom. Presumably also they give the magnetic properties, but this part of the problem is not yet wholly solved.

Now the X-ray spectra of the elements show that just as there are groups of a few characteristic lines corresponding to the agitation of individual electrons in Vegard's rings, so there are several continuous X-ray spectra having their maxima of energy at exceedingly short wave-lengths, implying orbital revolutions of very minute dimensions and very short period. These correspond to the continuous spectrum of the outer spherical shell resulting from ordinary thermal shock and appertain to the inner shells of mass-giving electrons which are disturbed by the penetrating cathode rays of the X-ray tube. Since the orbital velocities of the inner shells may be greater than those of the outer shell, we can not apply Paschen's rule with the same constant; but the known high temperature of the anticathode suggests that the *cores* of the bombarded atoms may be very much hotter than their surfaces. The excessively high velocity attained in the breaking up of the radio-active elements are attended by such extraordinarily high frequencies as those of the gamma-rays of radium.

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* S. P. Langley, "Sur les Spectres invisibles." Annales de Chemic et de Physique, 6e série, t. IX; 1886.

At present thermo-chemistry is less stressed than chemical electronics. Also the common-sense view that the mass of an atom is proportional to the number of electrons which it contains has been abandoned in favor of the view that mass is concentrated in an almost metaphysical "proton" which occupies almost no space at all, which has never been directly observed but is only inferred. Under such circumstances, it seems to me that no apology is needed for offering something concrete in place of metaphysical enigmas founded on mathematical abstractions. Spirit and matter are both real. They are the opposite faces of the shield. As Swedenborg says: "All power resides in ultimates." He did not use the term "atom," possibly because, with Plato, he rejected the idea of self-existent particles, incapable of division. But his series of composite elementary particles, formed from energy, has the closest affinity with modern discoveries.

As regards the mass-giving electrons in the atom, scientific opinion has fluctuated. In 1906, Professor Humphreys sought to explain the Zeeman effect and the pressure-shifts of the spectral lines on electromagnetic principles,* and spoke of the "total number of electrons per iron atom 5.10^4." These were supposed to be revolving congruously at a rate of about 1/600 of the speed of light within a sphere of "positive electricity." This "sphere of positive electricity" was a vague conception originally suggested by J. J. Thomson. If we substitute for it a shell of 50,000 positive electrons surrounding the 50,000 negative electrons of Professor Humphreys' specification, but revolving in the opposite direction, we shall have an atom which is both magnetically and electrically neutral. To possess magnetic properties the iron atom must indeed be furnished with electrons revolving congruously. These constitute a circular electric current, or solenoid. But these magnetizers are comparatively few in number and are in addition to the 50,000 neutral pairs. If all of the electrons in the atom were revolving so as to produce magnetic effect, the world would be so overwhelmingly magnetic that no other motion could exist than this internal magnetic one. Everything would be held fast in a rigid magnetic grip. Possibly it was the recognition of this *reductio ad absurdum,* in addition to the discovery of the tremendous importance of the Moseley number, which led to the abandonment of the conception that the atom has its tens of thousands of electrons; but this abandonment was unwise and unnecessary.

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* W. L. Humphreys, "An Attempt to find the Cause of the Width and of the Pressure-shift of Spectrum Lines." Astrophysical Journal, Vol. XXIII, p. 233, April, 1906.

Swedenborg was the first to suggest that magnetism is an affair of internal revolutions in elementary particles and that the production of a magnet consists in compelling the least particles of the iron to face one way. This explanation as rediscovered by Ampère is now accepted by science, as well as Swedenborg's further statement that matter is composed of elementary particles within which are revolving (as we should now say) thousands of particles of a finer order, and in accordance with his suggestion we may further surmise that these are themselves constituted by vortical motion of a host of particles of a still finer order, the whole forming a trine in three discrete degrees. At least we may say that science has verified the existence of the revolving electrons within the atoms, and is beginning to talk about "subelectrons," so that it looks as though the whole scheme would be eventually confirmed.

When I say "science" I refer to *physical* science, or the science of the physicists. The chemists still balk. Professor Gilbert N. Lewis, as recently as 1916, objected to the theory that the atom contains revolving electrons which continue to move at absolute zero. He says: "Now this is not only inconsistent with the accepted theory of electromagnetics, but, I may add, is logically objectionable, for that state of motion which produces no physical effect may better be called a state of rest." * But a magnet does not cease to be magnetic as absolute zero is approached, radioactive transformations are not affected by temperature, and, as J. J. Thomson has pointed out, if the internal electronic revolutions within the atom were to be immediately impeded or accelerated and the orbits enlarged or contracted by every thermal shock which the atom experiences, there should be no appreciable difference between the specific heat of a gas at constant volume and the specific heat at constant pressure, whereas this difference is a fundamental fact of thermodynamics; not that it is impossible to distort a revolving electronic ring, but that, if distorted, the ring immediately rebounds as if perfectly elastic.

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* Journal American Chemistry Society, Vol. XXXVIII, p. 773.

Science has come to the opinion that it is not possible to produce perpetual motion by any transference of mass-motions. But nevertheless, as Swedenborg taught, and as spectroscopic science abundantly confirms, perpetual motion is going on ceaselessly within the atoms. This motion, however, is not under our jurisdiction, for it can not be touched by the hand of man. Yet in our studies of glorious light, we seem to be approaching those sublime portals where Infinite Power is ceaselessly flowing-in and creating nature from moment to moment. Further progress in our studies requires a new inward illumination of the mind of man. Jesus said: "Greater things than these shall ye do, because I go to the Father." The spiritual is greater than the material and spiritual forces more powerful than natural. As we go deeper into the mysteries of matter we find nothing but *life* and motion.

Swedenborg's doctrine of particles is confirmed in respect to aurions, etherions and electrons, in so far as these conform to his model, as far as can now be determined. We are now able to experiment with single electrons, count them, observe their mass and charge by comparing these with the masses and charges of more accessible things. The research is conducted along rational and geometrical lines, but is checked by experiment at every turn. We can even determine the dimensions of an electron with fair accuracy.

We can state with the utmost confidence that etherions and electrons are distinct particles, or discrete entities, having a superficies which definitely limits the particle and an interior composed of actively moving particles of a higher order. Their constitution is obviously bullular.

But while the etherions and electrons are distinct entities, they are attended by magnetic and gravitational fields of force of indefinite extent, thereby linking them with a continuum and with infinity. The gravitational pulsations of an electron extend to the remotest stars of our Galaxy. The electron has at a given time a definite position in space, and yet, in a sense, it is everywhere.

The next step, however, is not a repetition of the same arrangement on a larger scale. The atom has not a continuous bounding surface, although it exhibits internal motion. Moreover, the atom is not bullular, unless a series of concentric spherical shells or groups of widely separated electrons can be regarded as in some respects the analogue of a system of concentric bubbles. But this has no relation to Swedenborg's idea. The bounding surfaces of ether particles and electrons are presumably composed of aural particles in contact. In fact, the aural particles appear to be everywhere in contact, since gravitational stresses are conveyed almost instantaneously. All material forms are defined by the motion of the aural particles which compose them. As Swedenborg says: "It is motion only which can give figure and space; without motion nothing could flow together into a bounded aggregate." We must distinguish, however, between the motion of a sheet of concatenated particles constituting a surface, and the unlimited motion of what Swedenborg calls an "active."

The atom also, although I have assumed that it corresponds to Swedenborg's "second elementary particle," is not the precise repetition of the vortex motion of the "first elementary particle" which, as we have seen, is the electron.

The atom, while it is a whirling swarm of electrons, is not a vortex after the original model. The series ends here. Swedenborg's thought of a constant succession of forms on the same model is not confirmed. A succession of particles of different orders is a fact, but there is endless variety in the means by which this succession is accomplished. The sphere recurs many times but is produced by different means. Bubbles and rain drops have the spherical shape, but are differently constituted. The air particle is not a bubble except in a modified sense. Steam is not produced by the expansion of the particles of liquid water into bubbles. The molecules are not spheres.

The structure which is described here is not identical with Swedenborg's second elementary particle, but it is analogous to it. Only one kind of component particles enter into its composition, but some of these function after a manner analogous to that of his finites and others take the part of actives.

SECTION E

SWEDENBORG'S DOCTRINE OF HEAT AND LIGHT, CONSIDERED IN RESPECT TO FREEDOM OF MOTION

One of the prime characteristics of the ether is the freedom with which it accepts every variety of luminous, or radiant vibration and disperses each sort independently. The degrees of freedom in the manifestation of forces in matter have recently been found to have far-reaching consequences. Freedom and light! How excellent are your fruits, both in matter and in spirit! Without intellectual freedom, the light of knowledge is quenched and dark ages of ignorance overwhelm mankind.

Two propositions stand forth clearly:

First, that the ether which conveys light must be perfectly free to assume every form of oscillatory motion. This proposition by Swedenborg is completely confirmed by spectrum analysis. There are no changes either in the velocity of propagation or in the nature of the vibration, as long as the light passes through free space.

Second, we have Swedenborg's teaching that there is a universal medium, or aura, in which there is virtual continuity—its elementary particles are maintained in a state of expansion and contact by the pressure of actives from within each particle. Here freedom is less immediate, because one thing has to regard another and conform to a more extensive plan. Various men of science have subscribed to the opinion that there must be some sort of continuity in a universal medium, though predicating modes of attaining this quality other than that assigned by Swedenborg. Mention may be made of Lord Kelvin, Osborne Reynolds, Sir Oliver Lodge, among others who have held this view.

On the contrary some of the relativity theorists deny that there is any universal medium; but against the deductions from the Einstein hypothesis, protests have been made by various astronomers and physicists.

Van Maanen's discovery of internal motions within the spiral nebulae along the arms of the spiral, seems to the writer to imply that there is a universal medium and currents therein which are superimposed on whatever motions gravitation alone can produce. Explanations founded on the hypothesis that nothing but gravity is acting, lead to serious discrepancies.

On the other hand, in the globular star-clusters, the evidence points to the existence of very great masses of matter and aggregations of stars so crowded that gravity exercises a control which aural currents can not overpower, Lord Kelvin calculated that if 1,000,000,000 stars, each of the sun's mass, started from a state of rest thousands of millions of years ago, under the influence of their mutual gravitational attraction, and are now uniformly distributed in a sphere whose radius is $30{,}900 \times 10^{12}$ km., the present mean velocity should be about 50 km. per second, which is a little more than the actual stellar motion. Central concentration in the swarm would give still larger speeds. But the results of recent parallax work make the dimensions of the Galaxy much more extensive without giving any corresponding increase in the velocities, thus casting doubt upon the gravitational control.

The central condensation of the Andromeda Nebula has a component of velocity of revolution in the line of sight which was spectroscopically determined by Pease to be 72 km./sec. at the radius 150″. E. Oepik (Astrophysical Journal, Vol. IV, p. 406), assuming that the motion is dominated wholly by gravity and centrifugal force, obtains for the nebular distance, 450,000 parsecs = 1,460,000 light-years, which is 22,460 times the distance of Nova Persei of 1901. The latter at its greatest brightness reached zero magnitude. But in August, 1885, a nova, which at maximum was at least as bright as the seventh magnitude, appeared near the center of the great Andromeda Nebula. This means that if the star had been as near to us as Nova Persei, it would have had a stellar magnitude of

$$7 - \frac{\log\ (22{,}460)^2}{0.4} = -14.8,$$

and would have shone like a small sun. The stellar magnitude of the full moon is only — 12.1. To escape from this extraordinary conclusion, we might assume that the very close alignment of the nova with the center of the nebula was only a chance coincidence (though the chances are enormously against an unaimed random shot hitting the bull's eye at only 16″ from its precise center), and that the nova was not in the nebula, which, as the number of known novae is small, and those outside the Milky Way are observed only in the spiral nebulae, is almost as extraordinary a fact as the other horn of the dilemma.

The value of one Andromede is now believed to be a little less than one million light-years.

Similarly, since our Galaxy has no brilliant nucleus, there is a strong indication that the matter of an original nucleus has been dissipated by expansion into a sheet of stars, that the Galaxy is spreading out over a much wider discoidal stretch than in the average spiral nebula, and is fainter or more diluted than we should expect for a body of its size, if of the same constitution as these bodies. This appears to be a fact. The strongly nucleated and brightest of the spiral nebulae have "an equivalent *visual* magnitude of from 17 to 18 per square second of arc," according to F. H. Seares,* whereas he obtains "21.0 as the photographic magnitude of the brightest parts of the clouds" of the Galaxy. From this value a small but uncertain color-index must be subtracted to give visual magnitude. The spectra of the spiral nebulae demonstrates that they are stellar aggregates, too far away to be resolved into their components. From all of these facts combined, I infer that ours is an exceptionally old galaxy which has suffered a wide dispersal. The brightest of the Galactic clouds in Ophiucus are to be compared with the very faintest wisps in the spiral arms of the white nebulae.

Given the expansion from outwardly spreading currents in the aura, the gravitational computation of Lord Kelvin is inadequate, and its results misleading. The stellar motions are not wholly due to gravity, but the stars are swept along in great aural vortices. Here we have a partial confirmation of one of Swedenborg's theories. (I omit the earlier theory of DesCartes which was too crude for any credence whatever). But observe! It does not apply to the planets, which are under gravitational control, but only to those stars which are so far apart as to be nearly free from such control. Neither does it apply to the globular star-clusters where gravity controls. The starry heavens are like a great republic where there is a minimum of control. They owe no allegiance to a gigantic central sun.

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* "The Surface Brightness of the Galactic System as Seen From a Distant External Point and a Comparison with Spiral Nebulae." (Astrophysical Journal, Vol. III, p. 1920.)

In the *Principia* (new English edition, Vol. I, p. 35) Swedenborg says:

> We see that all things are acted upon and put in motion according to laws; and that all flow from the motion and arrangement of small bodies of different forms in mutual contact.

Modern science confirms the existence of the "small bodies of different forms," but finds in regard to the small bodies of any given order that seldom are they in "mutual contact." Since Swedenborg formulated his theories throughout on this proposition, it is necessary to rebuild them in order that they may conform to facts. Nevertheless, the rational mind persistently comes back to the conception that somewhere in the series the idea of mutual contact must be fulfilled, or else there will be a breach of continuity and a lack of causation. This desideration may be obtained if it be admitted that the primitive medium, or universal aura, out of which all the small bodies which constitute the other media have been formed, is indeed composed of elementary particles in mutual contact. Given this fundamental proposition, it is no longer necessary that the *derivative* forms shall be in mutual contact, because, no matter how remote from each other they may be, virtual contact is still maintained through the intervening primitive medium whose particles *are* in contact.

In various forms, the basic conception has been repeatedly urged. Lord Kelvin's vortex-atoms predicated a continuous fluid in which minute vortices were formed once for all by Divine power and could never be destroyed. The scheme will not work, but its being put forward shows the persistency of the idea that somehow there must be mutual contact of parts. Osborne Reynolds imagined yet another mode by which mutual contact of incompressible particles might be invoked to account for a great variety of secondary groupings of these primary particles. We shall return to this later.

There are passages in the theological works which have been thought to indicate that Swedenborg eventually recognized that there were flaws in the *Principia* doctrine, even though its main thesis of series of interrelated forms still holds good. Thus in *True Christian Religion,* n. 20, he says:

> Unless an idea is formed of God as the primal Substance and Form, and of His Form as the absolute Human Form, the human mind may easily involve itself in spectral imaginations about God Himself, the origin of man, and the creation of the world. It would then concieve of God only as the nature of the universe in its first elements, thus as its vastness, or as emptiness and nothingness; of man's origin as a fortuitous concourse of elements into that form; of the creation of the world, that the origin of its substances and forms was geometrical points and their lines, which are essentially nothing, because nothing can be predicated of them. In such minds all that belongs to the church is like the Styx or Tartarean darkness."

In a sense, this repudiates the letter of some statements made in the *Principia;* but since Swedenborg also spoke of his points as having a nonspatial interior *conatus*, or effort to produce the most complex forms, he appears to have looked upon the points as centers of force involving interior spiritual causation and an external outflow of innumerable varieties of motion and form, derived, not from the points, but from the infinitely varied spirit behind the points. At the time the *Principia* was written this idea may not have been fully grasped, but it was present in embryo.

Incomparably richer and fuller are even the briefest statements of the Writings, where we are told that natural heat and light serve as clothing and aids to spiritual heat and light by which they may be conveyed to man. In T. C. R., n. 365, we are told that "natural heat and light are naked, but the heat and light proceeding from the Lord as a Sun, contain in their bosoms all the infinities that are in the Lord; the heat all the infinities of His love and the light all the infinities of His wisdom."

The farther back we go, or the nearer to sources, the more extensive are the relations of the individual particles, each of which is a center of wider or more complex fields of force and more vigorous motions as the order of the particle becomes finer. The microscope reveals some of the intricacies of the finer orders of material particles. Those of the least particles of the aura would defy description.

It does not seem to me that the passage in T. C. R., n. 20, is a repudiation of what Swedenborg is trying (though vaguely) to convey in the *Principia,* because the doctrine of "the first point" will bear the interpretation of a new point of departure, a transition in mode. The subject is treated more extensively in my "Prevision of Scientific Progress," page *7 et seq.*

The aura which unites the most diverse elements, has its affinities with heat.

Heat is a function of matter in mass,—light of the least individual parts within the atoms. A single molecule of matter traveling never so swiftly, can not be said to be hot, until by meeting other molecules, pressure is produced. In a Crookes dark space, where the nean free paths of the moving ions are so great that collisions are infrequent, no glow can be seen until, near the limit of the dark space, the ions begin to impinge on one another, setting up rapid deformatory vibrations by their impacts. The amount of thermal energy which can be contained in a body depends on its mass, and on its specific heat, or capacity for intramolecular and intra-atomic movement. The specific heat of elementary bodies is intimately related to the weights of their atoms, and to their internal pressures and motions. The connection between heat and pressure is most obvious in gases, which grow hot when compressed, but are cooled by expansion. Similarly, equilibrium within the atom is maintained by the interaction of electric repulsion and attraction, while variations of internal pressure arise, depending on the masses and motions of the electrons.

The wave-form of the curves expressing the thermal relations of the atoms, suggests structural variations of density within each atom, such as may result from the revolution of swarms of electrons in concentric annuli of a sphere. Each zone, or annulus of the sphere, has a speed of revolution appropriate to its radius, but all the speeds and pressures are related as are the terms of a harmonic progression. The principle which has given the Milky Way its discoidal concentration, namely, the most economical distribution of energy compatible with a given moment of momentum, is not involved in the production of orbital planes within the atom, because here the axes of the component electrons are not indiscriminately directed, but are arranged in continuous sequence and form circular lines of vortex-spin, as indicated in Swedenborg's theory of composite vortex-particles; for even if the electrons themselves are not in intimate contact, the magnetic spheres in the aura which accompany their motion, do coalesce into strands of aural vortex-spin. Such is the arrangement within the electron itself, except that here the lines of vortex-spin are spiral. The two-dimensional circular form of the internal atomic motion is demonstrated by the fact that the gases composed of monatomic molecules have only three degrees of freedom, which are those of the translation of the molecules in the three co-ordinates of space, which they possess in common with all gases through their intermolecular thermal movements; but molecules composed of *two* atoms at a fixed distance apart, have in addition *two more degrees of freedom* due to the revolution of the components about their common center of gravity in the two components of orbital motion. If the distance between the atoms also varies, still other two degrees of internal freedom are added.

While the thermal properties of matter are developed by pressure, and the science of thermodynamics has grown principally from the study of the mechanics of high-pressure steam, the peculiar luminous vibrations by which we distinguish different substances spectroscopically, are, on the contrary, best seen in rarefied matter, where the particles are relatively free, even as the illumination of the intellect is best exhibited where there is intellectual freedom. The solid and the liquid states lack the beautiful colored bands, and wonderfully marshalled ranks of lines arranged in mysterious order, which mark the spectra of gases. The molecules must be free to show their individual peculiarities. With larger numbers, they press on one another too much, the vibrations are damped, and there result broad, ill-defined spectral bands, and finally continuous spectra. There is power in numbers, but for penetration nothing can take the place of individual effort and specialization. We feel our hearts throb with the contagious enthusiasm of a multitude, but the clear vision of a difficult subject is best attained with a cool head in the quiet of the study.

The structure of the atom, considered thermally, is that of a system of revolving electrons distributed in annuli lying on the surfaces of spheres, each ring consisting of many electrons. These electrons are so numerous and so interrelated that the disturbance of one displaces them all, and generates a continuous spectrum, characteristic of solids with closely packed atoms.

Bohr, ignoring the dynamical difficulties urged by Thomson, postulates a stable orbit for a *single* hydrogen electron, which has been rejected by Langmuir for electrical reasons. Nevertheless, Bohr has disarmed critics by getting the Balmer series, a discrepancy which still requires explanation. The distinctness and constancy of the wave-numbers of a spectral series is best represented by motions of separate components, either rotary, oscillatory, or in independent orbits which must, however, be connected by some such spiral relation as the approximate one, known as Bode's Law, which expresses a connection between the otherwise disconnected orbits of the planets. The relation of spectral series is, in this view, the "Bode's Law" of the elements, here transformed into Bohr's Law."

Periodicity without continuity appears elsewhere, as in the atomic weights, of which Mendeléeff says (Principles of Chemistry, Vol. II, p. 20, note 11): "Many natural phenomena exhibit a dependence of a periodic character. . . . But in ordinary periodic functions one variable varies continuously, whilst the other increases to a limit, then a period of decrease begins, and having in turn reached its limit, a period of increase again begins. It is otherwise in the periodic function of the elements. Here the mass of the elements does not increase continuously, but abruptly by steps. . . . It is these properties which are the most important. . . . To explain and express the periodic law is to explain and express the cause of the law of multiple proportions, of the difference of the elements, and the variation of their atomicity and at the same time to understand what mass and gravitation are." The revival of Prout's hypothesis gives cause for the step-by-step sequence in the atomic weight; but periodicity requires the consideration of internal revolutions within the atoms and the degrees of freedom on which these depend. These are of very great importance in the theory of heat and as a confirmation of the several positions which Swedenborg assumes on this subject.

SPECIFIC HEAT OF GASES AND DEGREES OF FREEDOM OF THE ATOMS

Professor W. F. Magie, by an extension of Staigmüller's formula representing the division of thermal energy in a molecule, has arrived at some interesting conclusions in regard to the motions of atoms within the molecules. (Science, N. S., Vol. XXIII, p. 161, 1906). If J is the increase of thermal energy in unit mass of a gas in a confined space, and J_u is that part of the increase attributable to the translation of the molecules, each for a rise of temperature of 1° C., γ, the ratio of the specific heat at constant pressure to specific heat at constant volume, is given by the equation:

$$\gamma = 2/3 \, \frac{J_u}{J} + 1,$$

which is derived by dividing the energies of the molecules in unit volume corresponding to a change of 1° cent. into (*a*) energy of translation in three component directions, (*b*) energy of deformation of molecules by impact, on which temperature depends, and (*c*) energy of rotation of particles induced by oblique collisions. (See second example at the end of Chapter V of Preston's "Theory of Heat.")

Let k = the increase of kinetic energy corresponding to one degree of freedom, and to a rise of temperature of one degree in unit mass. Then the energy of molecular translation (J_u) increases by $3k$, and

$$\gamma = \frac{2k}{J} + 1.$$

The total increase of thermal energy is equal to the sum of the number of degrees of external freedom of motion (*a*) plus the number of degrees of internal freedom (*i*) increased by an unknown amount of potential energy. If we assume that the internal energy is equally divided between kinetic and potential, we must add an equal quantity of potential energy to each unit of internal kinetic energy, or *i*, which represents the degrees of freedom of internal motion, must be doubled. This gives the equation:

$$\gamma = \frac{2k}{(a + 2i)\, k} + 1 = \frac{a + 2i + 2}{a + 2i}$$

If m is the molecular weight, the quantity of thermal energy which can raise the temperature of one gram-molecule of the substance 1° C., is:

$$(a + 2i)\ km = Jm.$$

The value of km is found in the following way: From the velocity of sound in hydrogen, the velocity of the hydrogen molecules at 0° C. must be 1.842×10^5 cm. per sec. One half of the square of this velocity, multiplied by two, which is the mass of a gram-molecule of hydrogen, gives the total energy of translation, one third of which belongs to one degree of freedom at the given temperature, 273° absolute. We divide by 273 to get the energy corresponding to one degree Centigrade and reduce to thermal units by dividing by the mechanical equivalent of heat, 4.2×10^7 ergs, obtaining $km = 0.986$ small calory, which for most purposes may be taken as unity, and km may be omitted in the previous equation. The value of $J \times m$ being known, we can, in many cases, arrive at an estimate of the expression for the degrees of freedom.

If the atoms of a gas are elastic spheres, there is very little rotation produced by collisions, and the energy is almost entirely translational. In this case, $a = 3$ and $i = 0$. If a molecule is composed of two or more atoms arranged in a rectilinear row, a collision sets up a rotation in a plane containing the direction of the line of atoms and the direction of impact. The motion is two-dimensional and is in addition to that of translation. Hence $a = 3 + 2$, and if there is no internal distortion, $i = 0$. If the molecule consists of a number of atoms arranged unsymmetrically, or with more than one axis of symmetry, the rotation will be a compound, or three-dimensional one, and $a = 3 + 3$. This condition is the rule among all but the simplest molecules.

Let us now add the condition that a certain amount of thermal energy is used up in internal work, producing internal distortions. These are found to consist entirely of pendulum-wise vibrations in which one half of the energy is kinetic and the other half potential. The distortion may consist either in a rocking of the planes of orbital revolution of the ions, or in an oscillation of the eccentricity of the orbits about a mean value, but in either case the perturbations are slow compared with the periods of the electrons, and the latter are not appreciably affected unless the collisions are of great power.

This equipartition of internal energy between kinetic and potential has been considered probable from theory, but is now demonstrated through the verification of Staigmüller's formula which assigns equal values to i in the terms expressing kinetic and potential energy. Thus in the gaseous tetrachlorides of silicon, titanium and tin, and in the trichlorides of arsenic and phosphorus, the chlorine atoms have each four degrees of freedom, two potential and two kinetic, and $i = 2$, corresponding to some internal rotation. The arrangement of the atoms is not a linear one, consequently there are six degrees of external freedom. Hence the formula becomes for the tetrachlorides: Molecular heat at constant volume $= Jm = a + 2i = 6 + (4 \times 4) = 22$; for the trichlorides, $Jm = 6 + (3 \times 4) = 18$.

At high temperatures there is a much larger amount of internal energy. Thus carbon dioxide which has a linear arrangement, $o = c = o$, possesses one degree of internal freedom due to the variation of the distance of the oxygen atoms from the central atom without deviation from a right line. In addition, there are three degrees of freedom of translation and two of rotation, giving $a = 3 + 2$, $i = 1$, and $Jm = 3 + 2 + 2 = 7$. This is precisely the value of the molecular heat at constant volume for the temperature 50° C., but at 2000° C., $Jm = 20$. A large part of the variation in this instance is probably due to the exceptional character of the carbon atom. Carbon has about the normal atomic heat, 6.6, at the temperature of the electric arc, but this value falls to 2 at 0° C., and to 0.9 between —79° and —186° C., so that its atomic heat probably vanishes at absolute zero, and the large value of the molecular heat at 2000° C. is probably due to an exceptional expression of the carbon atom by heat. It will be remembered that carbon has the smallest atomic volume of any element, and the highest melting point and hardness.

Staigmüller's method having proved trustworthy for a considerable number of gases, it becomes possible to compute the degrees of freedom even in solid bodies from their known specific heats. When this is done, Professor Magie finds that the molecules of many carbon compounds are rigid structures in which each atom has but one degree of internal freedom, corresponding no doubt to the capacity of motion in a radial direction. Such are the alcohols, and the series of hydrocarbons from hexane (C_6H_{14}) to hexadecane ($C_{16}H_{34}$); but in many other compounds the atoms of different sorts may have either one, two, or three degrees of internal freedom. In some of the more complex molecules it is necessary to ascribe different degrees of freedom to atoms of the same kind. Thus the carbon atoms fall into two categories in the sugars whose identical empirical formulae receive new interpretations by this mode of attack. Denoting the degrees of internal freedom by accents, and the number of atoms in the usual way by subscript numerals:

Cane sugar $= C'_4\, C''_8\, H''_{22}\, O'_{11}$ $(i = 75)$,
Milk sugar $= C''_4\, C'_8\, H''_{22}\, O'_{11}$ $(i = 71)$,
Maltose $= C''_4\, C'_8\, H''_{22}\, O'_{11}$ $(i = 71)$,

The ordinary chemical reactions do not throw much light on the structure of these complex molecules, but thermal properties and absorption spectra promise to give some insight in this direction.

DISINTEGRATION OF THE ATOMS

The decomposition of the atoms has long been fruitlessly attempted by chemical methods. In a paper read before the Astronomical and Astrophysical Society of America at Washington in December, 1901 (published in full in the American Journal of Science, Ser. 4, Vol. XIII, Jan., Feb. and March, 1902), I suggested that "the breaking up of the atoms must follow new lines, must indeed be, in some respects, opposed to the processes which produce change of state in the molecular condition. Heat disappears in the rarefaction of matter. It should be evolved in its destruction" (p. 49). It was also suggested that the atoms are evolved out of the universal ether, (*i. e.,* what Swedenborg calls the "aura"), that an enormous amount of thermal energy disappears, or becomes latent in the formation of an atom, and that this underlying energy is set free by the disruption of the atoms. I said (*loc. cit.,* p. 55): "If we suppose that those atoms having large atomic weights have been formed by the expenditure of a greater energy, or that their latent heat of formation is relatively very great, the transformation of heavy atoms into lighter ones will set free an amount of energy equivalent to the difference in the heat of formation; but whether produced by transformation or destruction of atoms, the setting free of latent heat of atomic formation ought by analogy to develop relatively larger amounts of heat, or of energy to use a more elastic term, than transformations in the more compounded states of matter."

At this time there did not seem to be much prospect of
immediate verification of the hypothesis, but within a
tle over a year, P. Curie and Laborde (*Comptes Rendus,*
CXXXVI, p. 673, 1903) found that the wonderful sub-
ance, radium, is continually producing heat. Strutt's
pothesis that the α rays emitted from radium are positive
ns was confirmed at about the same time by Rutherford;
d in September of the same year Sir William Ramsay
d Mr. Soddy proved that the α rays emitted from radium,
well as from the radium emanation (niton), are com-
sed of the element helium.

The breaking up of the radio-active elements is attended
the production of three kinds of rays—α, β, and γ.
hese are respectively, atoms, electrons, and etherions; and
their trinal order, they suggest that here is a reversal of
e mode by which matter has been formed; that, in fact,
e rapidly vibrating etherions have been the *origin* of
atter, as pointed out in my paper: "What Becomes of
e Light of the Stars?" The third, or inmost degree of
atter, is therefore energy communicated by means of the
ght and subsequently formed into two succeeding degrees
hich are the electrons and the atoms. The atoms embody
ill another subordinate trine, shown in the analysis of
e positive rays of electricity, that is, there are three sorts
f generative subatoms. The trine in nature, pointed out
y Swedenborg, perpetually recurs.

The discovery of this tranformation is of such epochal
nportance that Dewar and Mme. Curie have taken pains
confirm it under circumstances which admit of no other
terpretation. A weight of about 0.42 gram of radium
romide was placed in a quartz tube, and the tube was
xhausted until no further gas came off. The bromide was
en heated to fusion, until about 2.6 c.c. of gas were

liberated. By this means every trace of helium was eliminated from the salt; but on sealing up the tube, a gas wa slowly evolved, and in a few weeks the existence of th entire spectrum of helium was demonstrated. This coul have been produced in no other way than by atomic disintegration.

Rutherford has since proved in the second edition of hi work on "Radio-activity," that radium, the radium emanation, the subsequent derivative of the emanation, calle radium A, and the next but one, radium C, as well as th last, or radium F, successively emit five atoms of heliu and that in so doing these successive products are themselves transformed into new transient elements. The hal duration of these elements varies from 3 minutes, in th case of radium A, to 136 days for radium F (polonium while radium itself is reduced to one half in about 173 years. Radium is now known to be itself an intermediat product derived from an other unstable element, uraniu

The heat given out during the successive transformatio of 1 gram of radium with atomic weight 224.2, to the fin product with atomic weight not much over 206, radio-lea is sufficient in the course of a year to raise 8760 grams water from the freezing to the boiling point. If this evolution of thermal energy continues unabated during th entire life of the element radium, the transformation this substance to a simpler atomic form will involve th production of over 10^9 gram calories (1,600,000,000) f every gram of matter. And this is but a small part of th total energy included in the atom. When a gram of mixe hydrogen and oxygen in the proportion of one to eigh is transformed with explosive violence into water, but 39 heat units are developed. *Three hundred thousand tim as much heat appears in the radium transformation.* Th amount of heat far exceeds that which can be produced by condensation under solar gravitation of the radiating sun sphere, and justifies the surmise which I made in the paper cited that solar heat is largely produced by the disintegration of unstable elements, and that the atoms are in reality only transient structures in the universal atmosphere.

In this connection, in 1906 I ventured to make another prediction, namely, that the so-called inert elements will be found to play a very important part in the formation of the atoms; and that their chemical affinity may be either nothing at all, or practically infinite. In the latter case their compounds are undecomposable, and we call them elements. But under certain circumstances, which hitherto have been beyond our control, this infinite affinity may be partially abrogated, setting free enormous quantities of energy.

Professor Piazzi Smythe found that certain gases in vacuum-tubes ceased to glow after many years, and in their place was seen the spectrum of hydrogen. Lockyer, from the abundance of hydrogen and helium in the atmospheres of the younger and hotter stars, and the comparative absence of metals, inferred that the metals were dissociated into hydrogen and helium. Ramsay and Soddy found that radium gives off, in addition to helium, an unknown gas with spectral lines of wave-lengths 6180, 5695, and 5455 A. These lines form a harmonic series. Two of them, λ 5695 (intensity 6) and λ 5455 (intensity 1), together with what is probably a fourth member of the series at λ 5325 (intensity 1), were observed by Pickering in the first spectrum of *Nova Persei* on February 22, 1901. They suggest that profound atomic disintegrations were concerned in this gigantic stellar explosion.

The hypothesis that the exceptional prevalence of helium in the hotter stars might be due to destruction of unstable atoms and that this is the source of the enormous stellar heat, could only be put forth by me as a surmise in the early stages of the doctrine, but is now rendered practically certain through the actual transformation of our most refractory elements into helium. Thus Anderson by concentrating a most powerful electric discharge on a very fine wire of tungsten, produced a blinding flash and a deafening detonation, and after the explosion nothing was found where the wire had been but a little helium gas.

Dr. Louis Bell, on December 29, 1922, described before the American Astronomical Society experiments in which the spectrum of a peculiar "negative tongue," which appears at currents of 100 amperes and upwards in a very powerful carbon arc, showed many lines of helium. Here the atoms of carbon have apparently been disintegrated and helium is at any rate one of the products.

At present we can affirm that the atoms are decomposable and that hydrogen, helium, and a third gas of unknown composition result from the disintegration. The suggestion which I made in 1906 (for which see my paper on "The Wasting of Stellar Substance" in Scientia for April, 1920) that the third substance may be nebulium, is not yet confirmed, and the status of this substance still remains a mystery; but we are evidently on the verge of most important discoveries in regard to the composition, or at least in regard to the derivation of the atoms and the results of their disintegration—all of which completely confirms Swedenborg's assertion that elementary particles are compounded of simple ones, however, much it may be necessary to revise some of the details of his thesis.

GENERAL PROPERTIES OF THE ATOMS

(*Summary*)

We have seen that there is a necessity for two general atmospheres, one discontinuous and locally distributed, the ether, and the other the omnipresent aura, which are distinct, although interpenetrating. The ether is formed out of the aura by the impression of some sort of circulatory motion upon the aura. This rotation may be that of a structure of vortex-filaments in the aura which need not give the property of mass unless the ends are closed in vortex-rings. The latter pulsate and have gravitation, and are also controlled in their movements by magnetism. The negative electrons are probably pulsating vortices in the aura, and the positive atomic charges may be complementary vortices, not necessarily of a different kind, but having a different presentation as indicated by Swan's experiment. The atoms are probably spherical vortex-aggregates of aura somewhat after the Hicks type, within which clusters of electrons revolve in harmonically spaced rings with enormous velocity. Whether these vortices are those of positive and negative charges interpenetrating, or whether the positive charges are distinct and centrally situated, is a question which must be reserved for separate investigation, and has been given a preliminary treatment in my paper on "The Luminiferous Ether." The electrical attractions so greatly exceed those of gravitation that centrifugal force can not disrupt these revolving rings except in circumstances of special instability.

The atoms appear to be ordinarily elastic spheres, but may open out into rings in certain cases, and change their volume. (Cf. *ante*, p. 237-573.) Their polarity is due to the circulation of the electrons or possibly of sub-atoms composed of electrons, in orbital planes. The formation of subatoms, as in Swedenborg's air particles would account for the very wide range in some atomic volumes, but has never been confirmed. In general, the internal circulations are arranged in some sort of alternation, so that but little atomic magnetic force is produced; but in iron there must be an exceptional congruity in these motions, since its magnetic effect far exceeds that of any other substance. Given the magnetic atoms, these may be either indiscriminately oriented, as in soft iron, or arranged in axial parallelism, as in the steel magnet, according to Swedenborg's theory of the lodestone.

It has seemed somewhat doubtful whether needle-shaped particles of iron, such as are drawn in Swedenborg's figures 19 and 20 in the *Principia,* would actually be free to turn in a *solid* mass of material in its becoming magnetic, in fact, the existence of magnetic hysteresis and reluctance to assume the magnetic state show that the freedom of the particles to turn is not perfect; but the turning of minute rectilinear magnets when floating in free air with each cycle of an alternating electric current, producing a flickering appearance, is described by Dr. Elihu Thomson in Science for July 29, 1921. The phenomenon was first observed by a workman in the General Electric Company's works at Lynn, Mass. A more instructive experiment was shown at the meeting of the American Association for the Advancement of Science in December, 1922.

Vapor of iron from an iron arc-light, composed originally of monatomic molecules, but condensing into minute spherical particles, introduced into a cylindrical chamber with glass ends, surrounded by a coil of insulated wire. The particles are about 0.1 μ (or 1/10,000 m.m.) in diameter and are entirely similar to the globulites whose dendritic festoons form the first initiaments of crystalline ructure when crystals are produced from free liquids. nese tiny globular particles of iron are magnetic and can rotated when a magnetic field is exhibited among them passing an electric current through the coil of wire. In is form, however, there would not be sufficient friction communicate any motion form their rotation to the air which they float. But like the mineral globulites, they nd to adhere into chains (margarites) which are definite ctilinear microscopic magnets, the fundamental units of e iron crystal.

Now the magnetic aura enclosed in the cylinder is rotting about the axis of the cylinder when the magnetic eld is produced, because it is electrically controlled, and e tiny magnets are carried along in this current, placing emselves parallel to the polar axis; and with them they rry small amounts of air, the appearance being somewhat milar to the structure of commingled convection currents en over a hot plate, except that the latter rise up vertically, hereas the currents in question revolve around the magetic axis and can be instantly turned from a right-handed a left-handed revolution when the magnetic field is reersed, the little magnets being turned end for end. When e interior of the cylinder is strongly illuminated, the otion of the air, carried along by these almost ultraicroscopical bodies, becomes plainly visible.

The series of operations is as follows: Currents in the ura, which in the themselves would be unable to affect the ir, so different is the order of magnitude of the air and ural particles, play upon the electronic circulations in the ny margarites, controlling the pointing of their axial lines nd carrying them along in the aural current. These movng magnets, in turn, communicate motion to the air by imple friction and the air currents (resembling those of thermal convection), when properly illuminated, can be seen by the naked eye.

Note also that the form of the aural vortex as thus mapped out is entirely similar to that described by Swedenborg and consists of both an internal circulation around the longitudinal polar axis of the magnetic field, and of a further circulation (around a circular line which defines the magnetic equator) which is mapped out by the magnetic phantom.

SECTION F

Atomic Piling in Solids. Constitution of Matter and Formation of Matter from the Basic Aura. General Conclusions from Swedenborg's Scientific Philosophy in Respect to Heat and Light.

atomic piling in solids

In crystalline solids, molecular groups are not especially prominent; but gases contain groups of atoms sometimes symmetrically arranged, but often quite unsymmetrical. These molecular groups do not form spherical particles (except where myriads of them are gathered to form globulites), nor is there any further atmospheric recurrence of the spherical form, save for its occasional recrudescence in that very rare phenomenon—ball lightning. A reminiscence of the elementary vortex-particle is seen in smoke rings which, however, have no particular dimensions and are evanescent, as are bubbles.

Incipient crystals exhibit a recurrence of the spherical form in the microscopic globulites which are arranged in rows to form dendrites (wherein is embodied another variety of the radiating principle), whose interlacing branches alesce to produce crystalline complexes. A final recru-scence of the spherical form in the mineral world is given here particular substances separate from solid magmas crystals which radiate from centers, as in the calcareous ncretions of certain sedimentary rocks, or the spherical ncretions found in lava and volcanic glass. These may tain considerable size, but have no definite dimensions and e in no sense to be likened to spherical, still less to bul-lar particles. We must therefore deny the existence of herical particles formed by motion in any higher than e third or atomic order.

The atoms in solid bodies are closely packed with only slight range of motion. The special stereochemical molec-ar grouping of the atoms, where each group has an in-viduality of its own, exist only in the free liquid and aseous states and are abandoned in the solid state for a ore closely consociated formation with regular, systematic omic piling in interlaced space-lattices. An exception is und in certain sublimated crystals, formed in free air. hus snowflakes show hexagonal tablets of trihydrol with olecules having three oxygen atoms in a triangle and six ydrogen atoms at the corner of the hexagon indefinitely peated; but ice which has been compressed has the prop-ties of dihydrol.

The attraction between atoms of the same sort is insuf-cient to overcome the virtual repulsion due to their exter-l thermal motion, and hence they are arranged in normal ctangular piling as a rule; but if atoms of another kind e interspersed, as in compounds (where reasons of stereo-emistry may dictate the pattern), the more powerful emical affinity of the added atoms may pull the alternate yers of atoms into positions of diagonal piling, or what wedenborg calls the "fluid quadrilateral pyramidal, or natural" position. This has been shown by Fessenden ir special cases. "If we take 45 c.c. of potassium and 18 c.c of solid chlorine," says Fessenden, "they can unite chemically to form a quantity of KCl occupying a space of but 37 c.c." From the relation: Weight = volume × density we may compute the atomic volume = atomic weight ÷ density. The numbers just given are not very differen from the atomic and molecular volumes of the three substances, potassium (45.5), chlorine (22.9), and potassiun chloride (37.5). If 100 spheres, "each having a diamete equal to that of a cube containing .45 c.c." are arrangec in normal piling, they will fill a space of 45 c.c. "Take nov 100 other balls, each having a diameter equal to the sid of a cube whose volume is .18 c.c., stack them in rectangula order, and they will occupy a space of 18 c.c. Next arrange alternate layers of large and small balls" with th larger in diagonal piling. "On measuring the volume nov occupied by both sets of balls it will be found to be nearl 37 c.c." ("A Determination of the Nature of the Electri and Magnetic Quantities," Physical Review, Vol. X, p. 9 1900.)

In quadrilateral pyramidal diagonal piling the ratio o occupied to unoccupied space is 2.7 times as great as i the closest normal piling. The condensation in passin from normal to diagonal piling is from volume 1.00 t volume 0.70. The ratio of occupied to unoccupied space i diagonal piling of the above order is 2.97 : 1, that for norma piling being 1.10 : 1; that of the original atomic volume in the preceding experiment is 45 : 18 = 2.5 : 1. Consequently, in this case there is room enough for interpenetration with very little distortion of the atoms, but th observed values require condensation even at their closes approach.

I am unable to find any measurement of the atomic volume of *solid* chlorine. The value adopted by Fessenden assumes that solid chlorine is somewhat denser than liquid. The density of the latter at very low temperatures is given as 1.71 by the best recent authorities, which is near the mean of all measures. At 15° C. under 4 atmospheres pressure chlorine condenses to a yellow liquid of density = 1.33. Its atomic volume covers a wide range and an approximate mean value will best express the condition of its atom in solid compounds. With Richards I shall adopt 1.55 for this mean density.

On the whole, it seems probable that there is some atomic contraction in combination of elements. We have atomic volume = atomic weight divided by density.

Atomic volume chlorine (Cl) = 35.46/1.55 = 22.9 Sum
Atomic volume potassium (K) = 39.10/0.859 = 45.5 68.4
Molecular volume sylvite (KCl) = 74.56/1.987 = 37.5.

The cube root of the atomic volume may be regarded as the side of a cube, or as the diameter of a sphere indifferently, if the atoms are in normal piling. But it will make a difference if atoms of different sizes are to be combined. If the particles are cubes, there are no vacant spaces to receive inclusions, whereas spherical particles permit the inclusion of smaller spheres and even of fairly large ones if these are arranged in diagonal piling with the larger spheres, possibly without deformation. If the K-atoms are in normal piling, there will be room for alternate layers of Cl-atoms with their centers raised ½ radius of a K-sphere above the level of the latter (*i. e.*, the plane of the Cl-atoms midway between those of the K-atom), even with the atomic volume of Cl = 22.9. But if the K-piling is quadrilateral pyramidal, which it must be to give the molecular volume of KCl = 37.5, the atomic volume of Cl cannot be greater than

18, as stated by Fessenden. Hence it appears that one or both of the atoms have been condensed by the pressure of their mutual attraction in forming sylvite.

We may compare these data with the computation given by Swedenborg in which he shows that the occupied space with spheres in normal piling is 0.52381 of the whole and in fixed quadrilateral pyramidal piling it is 0.74830 of the whole, the ratio of which is $0.748/0.524 = 1.43$. Here if the K-atoms remain in normal piling, an equal number of Cl-atoms may be accommodated in the interstices without much of any change of volume and with but little more change of density in the compound than would come from the addition of the two densities. But since the molecular volume of sylvite is actually less than the atomic volume of potassium, we conclude that the potassium has been pulled into diagonal piling in the sylvite. We decide in favor of the quadrilateral pyramidal position, rather than that of the triangular pyramidal position, because the crystals are cubes.

The proposition has now been subjected to farther tests through the X-ray analysis. The structure proves to be more complex than we have imagined. Various lattices are interlaced in the crystal in a complicated way. In their work on "X-Rays and Crystal Structure," by W. H. Bragg and W. L. Bragg, London: 1915, these authors apply the test to the alkaline halides and say (pages 94-96):

> As we are going to compare KCl [potassium chloride] and NaCl [sodium chloride], let us call the metal R. We can then denote the constitution of the (100) planes [parallel to the faces of the cube] in both cases by saying they contain RCl. The (110) planes [cutting off the twelve edges of the cube] are built up in the same way, but their distance apart is smaller in the ratio $1 : \sqrt{2}$. The (111) planes [cutting off the eight corners

of the cube] are of a different nature, however. The successive planes contain R atoms alone and Cl atoms alone alternately. If we reflect the X-rays from the planes (111), . . . half way between the planes of composition Cl are spaced planes of composition R. These reflect waves which are, for the first reflection, just out of step with (i. e., in opposite phase to) the waves reflected from the Cl planes. Their effect is to tend to destroy the first reflection, and in fact every reflection of the odd order, while they strengthen the reflections of even order. This effect is apparent in the spectrum of (111) NaCl, where the planes containing sodium of atomic weight 23 alternate with the planes containing chlorine of atomic weight 35.5. In KCl (111) the atomic weights (39 and 35.5) are so close that the spectra of odd order are absolutely cut out.

Thus the answer to our question is by no means simple, but it confirms the existence of lattice-piling of atoms in crystals, and consequently Swedenborg's incipient conception of crystalline structure as due to the arrangement of spherical particles (which we should now call atoms) in layers with various kinds of piling, is also confirmed. But his ideas in regard to further complex aggregations of particles (possibly in some respects resembling what we should now call molecules) considered as constituted by a dovetailing of solid particles of divers shapes, are not supported. The molecules are, indeed, aggregations of atoms, of which some of the subordinate groups necessarily form various geometrical figures; but the atoms are not held together by any such bonding as that of bricks in a wall, but by chemical bonds which are the electric and magnetic forces between certain configurations of selected electrons within the atoms. Molecules exist in solution and in colloidal solids; but in crystals molecular structure is overruled by the requirements of various lattice-structures of which the atoms are the units, so that molecules are not free to exist, except in certain specified directions, as we have seen. This overthrows the entire basis of Swedenborg's "chemistry."

The arrangement of the atoms in solid bodies, their piling and surfaces of alternation, determine the crystalline form. Swedenborg was the first to perceive that such an explanation is possible, but owing to the absence of chemical facts at that time, his "Principles of Chemistry" (published at Amsterdam in 1721, English translation, London, 1847), although an ingenious speculation, was a comparative failure. We must distinguish between the stereochemical conception of piling in solids as a comparatively simple proposition which was right, and the errors arising from the assumption that atoms can have peculiar angular shapes. His inference that water is composed of two sorts of particles in the proportion of one to eight has sometimes been instanced as an illustration of genuine prediction, but it was only a lucky hit in a considerable number of guesses, which were generally wrong. He deserves credit, however, for the invention of the conception which has now been applied with success in the determination of a lattice structure of atomic piling in various crystals as deduced from the interference pattern of their X-ray spectra. Certain anisotropic crystals conduct heat differently along each of their inclined crystalline axes. This was unknown in Swedenborg's day, but is all explicable from the laws of atomic piling which he originated.

SWEDENBORG'S BULLULAR HYPOTHESIS IN RESPECT TO THE ORIGIN OF PARTICLES

Admitting the spherical form of the particles, there was further reason for speculation as to why this form had been assumed. Swedenborg founded his theory of elemental forms on the postulate of a universal medium composed f least parts, "actives," and "finites," in conjunction of hich "each one is most perfectly similar to the other." 'here is a fundamental unity in nature which demands a nifying principle, a fundamental substance, or "protyle," s Crookes calls it, embodied in a form indefinitely repeated, ut of which infinite diversity can flow without violating he law of continuity and similars. If there be says Sweenborg, "a least substantial, and if in this substantial there e latent a cause of producing a new finite, then we can onceive the existence of only two contingents, one being his: That so great is the abundance of smallest substanials, that one by contact presses upon the other, a coningent from which exists a new finite. The other, that he abundance of smallest substantials is not so great that ne by contact presses upon another, a contingent from vhich exists the active of the first finite." (*Principia,* Pt. 1, Chap. 4, Art. 5). "In respect to this active, finites conatenated in a series or in an aggregate, are passive. In an lementary particle, finites constitute the superficies, and ctives . . . the internal space. . . . Hence we arrive at a oundary of a space, yet not resulting from the actives, which terminate nothing; but from the volume of the finites which surround them." (Chap. 6, Arts. 3 and 4; see also Fig. 10, English Ed., p. 141.) Atmospheres consist of particles and the particles, even if not in intimate contact, must be kept expanded from within by energy, that is, by heat.

Here we have the origin of Swedenborg's conception of his "bullular" hypothesis; and as regards the initial particles of the aura it is hard to imagine any other, at least, if we reject this, we shall probably be driven to the conclusion that the origin of the primal elementary particles is an insoluble mystery. To this extent the bullular hypothesis seems to be justified. But when we try to imagine the pr duction of further forms by the combination of these prim particles, we see that Swedenborg's "two contingent cease to be the only ones possible, but there must be indef nitely many modes of conjunction. *Duality* and a combi ation of active and passive particles may, indeed, recur, a for example, stationary are combined with revolving ele trons in the atom. But the stationary electrons are for th purpose of uniting the atoms to form compounds. The do not limit them and are too few in number to do so; whi the revolving electrons are classified as those which giv the high-frequency vibrations which produce the characte istic lines of the X-ray spectra, to which must be adde other groups which give the lines of the principal serie those giving series of diffuse and of sharp lines, other giving various combinations, those which produce the nu merous groups of lines of resonance spectra, and so o The atom is an exceedingly complicated thing. It consist of a great variety of interlaced forms of motion, and neve again do we have the simplicity of the original suggestio of only two contingents.

OSBORNE REYNOLDS' BULLULAR HYPOTHESIS

The conception of elementary particles, formed a vacuoles in a space everywhere filled by passive finites except where these are pressed back by circumferentia motion about innumerable centers, has been revived in it most extreme form by Professor Osborne Reynolds in hi work, "The Submechanics of the Universe." From hi experiments on the motion of sand "which reveal dilatency as the ruling property of all granular media," and from his investigations of the motions of viscous fluids, Reynolds was led to postulate a universal, purely mechanical medium composed of smooth, perfectly spherical, infinitely resistant granules, or "primordians," incapable of distortion, everywhere in contact, except at certain singular surfaces of discontinuity, or freedom, which limit the vacuoles, or masses of negative inequalities constituting the atoms.

This hypothesis completely reverses the usual conception of a universal atmosphere of extreme rarefaction in which are limited volumes of "dense" matter. Instead, we have a universal dense medium in which are scattered spaces of vacuity, or of negative mass, constituting what we call matter. The real mass is that of the medium and moves in the opposite direction to that of the negative inequalities, just as when a bubble rises in water, an equal volume of water descends to take its place. "Gravitation is not the effect of masses present but of masses absent." Just as two bubbles attract each other, so two negative inequalities in the medium are pressed towards each other. Gravitational strains in such a medium become a matter of stresses from strained abnormal piling of grains everywhere under pressure. This removes a difficulty and gives an exceedingly simple explanation of gravitation, but introduces other discrepancies. In such a medium there can be no vortices. The velocity of transmission of gravitation can not greatly exceed that of light. Bound ether is an impossibility. Discrepancies between explanations of electric forces and the facts of experience appear, and if, as the author claims, there can be no other purely mechanical system, we must conclude that the natural world is not purely mechanical.

Osborne Reynold's theory of the material universe can hardly escape shipwreck on certain electrical propositions. It is hard to see how his *outside pressure* is to be produced, and this pressure is necessary to keep his "sand-universe" together. The theory looks very much like a "house built upon the sand" and doomed to fall. But if Reynolds is right as far as his mathematical argument goes, and if, as he says, his is the only possible "mechanical" universe, then it would seem to follow that the universe is not simply a machine. Does it not have a human quality infused into all its workings? There is evidence on every hand of wonderful prevision and intelligence in the construction of the universe. There is love in the universe—yes, even in nature—superintending and moderating the rigors of a heartless mechanism.

There is considerable doubt as to the ability of Reynolds' hypothetical granular medium to do what is required of it. In the first place, will it flow? for without fluid properties we can not have a universe. Undoubtedly under some circumstances sand flows very much as a liquid is supposed to do. But there are some remarkable divergences of properties. C. E. S. Phillips showed an experiment at the Royal Institute in 1910, which is thus described by Lieut. Col. R. de Villamil in his "ABC of Hydromechanics" (p. 24-25):

> Take a small tube of about the diameter in the sketch [Fig. 11] and open at both ends. Cover the bottom with a cigarette paper, fastened on by an elastic band. The tube is then partially filled with fine dry sand and a piston is inserted on the top of the sand. As the sand does not "flow," by carefully applying weight to the piston (as shown by arrows), the weight of a man can be suspended from the piston. It is hardly necessary to say what would happen if water had been put into the tube instead of dry sand.

And Villamil summarizes the properties of a liquid thus (p. 25):

> A liquid flows—can only flow—and must flow from a region of higher pressure to region of lower pressure.

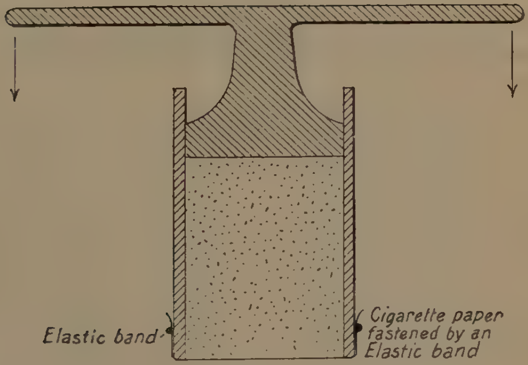

FIGURE 11.

A liquid does not, under ordinary conditions, obey [the law of rectilinear motion.] When it is stressed it does not move in a straight line, in any direction.

As the velocity of a liquid increases its pressure decreases.

A stream of liquid can only increase its velocity by converting some of its potential energy into kinetic energy.

Kinetic energy can not be directly conveyed to a liquid. An energy transferred must be potential.

In nearly all that Swedenborg says about motion in his *Principia,* he is talking, not about Newton's laws, but about liquid motion, which is what is described in the foregoing definitions, and these principles are correctly applied by him to atmospheric motion, if we grant the contiguity of particles. Here, however, some exceptions must be taken.

Some further fundamental principles which underly the foregoing condensed statements are given by de Villamil on page 21, where he quotes Rayleigh (Phil. Mag., 1876):

The relation between the velocity and pressure in a steady stream of incompressible fluid may be obtained immediately by considering the transference of energy along an imaginary tube bounded by stream-lines.

In consequence of the steadiness of the motion, there must be the same amount of energy transferred in a given time across any one section of the tube as across any other.

"Now, if p and v be the pressure and velocity respectively at any point and ρ be the density of the fluid, the energy corresponding to the passage of the unit of volume is $p + \frac{1}{2}\rho v^2$, of which the first term represents the potential and the second the kinetic energy; and this $p + \frac{1}{2}\rho v^2$ must retain the same value at all points of the same stream-line.

This, says de Villamil, may be considered the formula in hydrodynamics which especially interests engineers, and it will be frequently referred to. Not only is the energy (potential + kinetic) constant all along the same stream-line, but it is the same for all the stream-lines in the same horizontal plane.

(Ibid., p. 22) All the parts of a liquid in steady motion must be under lower pressure than those parts which are at rest, or are moving at a lower velocity. Also, the greater the velocity the lower will be pressure.

As a perfect fluid has no viscosity, it may be said to have no "expenses"; its capital will never diminish.

Water obeys the same law exactly, with one exception, and that is that $p + \frac{1}{2}\varrho v^2$ is not constant, but is always diminishing slightly. Its viscosity causes the particles to rotate and so rub against one another. Energy is converted into the heat form, which is dissipated and so lost—to the water. In other words, water has "expenses" and so is living on its capital, which is therefore constantly decreasing.

Further on (Ibid., p. 41) we read:

Fluid friction is caused by a stress set up in a liquid to resist shearing.

It increases as the velocity only.

It is not affected by pressure [except that the viscosity of water is slightly lowered by pressure (T. E. Thorpe, Royal Institute, 1898.)]

At a "critical speed" the liquid suddenly breaks into eddies.

The resistance of a body moving in a viscous liquid can therefore be expressed by $R = AV + BV^2$, where AV is the resistance due to viscosity, and BV^2 that due to eddy-making.

Viscosity is not in general the cause of eddies, it actually tends to prevent their formation and to stop them when formed.

(Page 40, Ibid., quotes Osborne Reynolds):

Circumstances conductive to direct or steady motion:

1. Viscosity, or fluid friction which continually destroys disturbances (treacle is steadier than water.)
2. A free surface.
3. Converging solid boundaries.
4. Curvature with the velocity greatest on the outside.

Circumstances conducive to sinuous or unsteady motion:

5. Particular variation of velocity across the stream, as when a stream flows through still water.
6. Solid boundary walls.
7. Diverging solid boundaries.
8. Curvature, with the velocity greatest on the inside.

These principles are of importance in discussions bearing on vortex-motion in fluids, for example, by the successive juxtaposition of like-named poles of the polar particles of a universal magnetic medium, directive forces are applied to what would otherwise be a frictionless fluid. Throw these aural vortex-filaments into closed curves, as in electrons and etherions, and great permanence is manifested. The most frictionless of fluids has now become the most viscid, as to its specially circumscribed motion, and the form of that motion assumes an extraordinary permanence because it continually reenters into itself.

Swedenborg's doctrine that the universe is "sustained" by perpetual spiritual influx does not demand the impossible by predicting a frictionless aura which, nevertheless, can have special forms imposed upon it and retain them; but an aura whose "expenses" are renewed, comes the nearest of anything we know to a permanent and frictionless substance.

ON THE NECESSITY OF NON-NEWTONIAN MECHANICS IN PROBLEMS OF RADIATION

We have seen how intimately connected are the problems of the constitution of matter with those of heat and light. When light-quanta which have been emitted from heated matter are reabsorbed by matter, the whole of the luminous energy which goes back to the material form enters into the transaction, and not the half as is the case in the partition of energy between the two parts of a reacting mechanism in ordinary mass-mechanics. Thus, although an etherion possesses mass, it d,oes so temporarily, or only so long as it preserves discrete individuality. When energy is exchanged between two portions of ordinary matter, the Newtonian maxim: "Action and reaction are equal," always holds and the half-and-half rule is fulfilled. But the etherion is formed out of the aura instantaneously at the expense of a small part of the energy of an electron whenever the latter finds itself unclothed by an ethereal sheath, and such energy as exists in the light-quantum disappears with equal instantaneousness where there is immediate absorption by a material structure.

The theory is clearly explained in a passage in Planck's work, "The Theory of Heat Radiation," translated by Masius (p. 56 to 58), which I shall quote in full.

> In view of the extraordinary simple and close relation between the radiation pressure and the energy of radiation, the question might be raised whether this relation is really a special consequence of the electromagnetic theory, or whether it might not, perhaps, be founded on more general or thermodynamic considerations. To decide this question we shall calculate the radiant pressure that would follow by Newtonian mechanics from Newton's (emission) theory of light, a theory which, in itself, is quite consistent with the energy principle. According to it the energy radiated onto a surface by a light ray passing through vacuum is equal to the kinetic energy of the light particles striking the surface, all moving with the constant velocity c. The decrease in intensity of the energy radiation with the distance is then explained simply by the decrease of the volume density of the light particles.
>
> [It must be remembered that Newton's light particles differ in no wise from the particles of ordinary matter, except perhaps in being unusually small. The light particles are supposed to be rigid, structureless and indestructible, equally with material particles, in Newton's view. They should therefore possess mass equally with material particles and the mass should be of the same kind.]
>
> Let us denote by n the number of the light particles contained in a unit volume and by m the mass of a particle. Then for a beam of parallel light the number of particles impinging in unit time on the element d_σ of a reflecting surface at the angle

of incidence θ is nc cos θ $d\sigma$. (67)

Their kinetic energy is given according to Newtonian mechanics by

$$I = nc \cos\theta \, d\sigma \frac{mc^2}{2} = nm \cos\theta \frac{c^3}{2} d\sigma. \quad (68)$$

Now, in order to determine the normal pressure of these particles on the surface, we may note that the normal component of the velocity c cos θ of every particle is changed on reflection into a component of opposite direction. Hence the normal component of the momentum of every particle (impulse-coordinate) is changed through reflection by $-2mc \cos\theta$. Then the change in momentum for all particles considered will be, according to (67),

$$-2\, mn \cos^2\theta \, c^2 \, d\sigma. \quad (69)$$

Should the reflecting body be free to move in the direction of the normal of the reflecting surface and should there be no force acting on it except the impact of the light particles it would be set in motion by the impacts. According to the law of action and reaction the ensuing motion would be such that the momentum acquired in a certain interval of time would be equal and opposite to the change in momentum of all the light particles reflected from it in the same time interval. But if we allow a separate constant force to act from ouside on the reflector, there is to be added to the change in momenta of the light particles the impulse of the external force, i. e., the product of the force and the time interval in question.

Therefore the reflector will remain continuously at rest, whenever the constant external force exerted on it is so chosen that its impulse for any time is just equal to the change in momentum of all the particles reflected from the reflector in the same time. Thus it follows that the force F itself which the particles exert by their impact on the surface element $d\sigma$ is equal and opposite to the change of momentum in unit time as expressed in (69)

$$F = 2\, nm \cos^2\theta \, c^2 \, d\sigma$$

and by making use of (68),

$$F = \frac{4\cos\theta}{c} \, I.$$

On comparing this relation with equation (64)

$$[F = \frac{2 \cos \theta}{c} I]$$

which is Maxwell's equation for the pressure of light deduced from theory and confirmed by experiment, in which all symbols have the same physical significance, it is seen that Newton's radiation pressure is twice as large as Maxwell's for the same energy radiation. A necessary consequence of this is that the magnitude of Maxwell's radiation pressure can not be deduced from general energetic considerations but is a special feature of the electromagnetic theory and hence all deductions from Maxwell's radiation pressure are to be regarded as consequences of the electro-magnetic theory of light and all confirmations of them are confirmations of this special theory.

On page 39, Planck says: "According to Helmholtz's law of reciprocity, the decrease which the energy of a ray suffers on any path is always equal to the decrease suffered by the energy of a ray pursuing the opposite path."

In regard to this statement it seems to me to be true as long as the energy continues in a free, or reversible condition. But when energy passes into the entropy and can not be restored as free or sensible energy by a direct reversion, the restoration to the state of free energy takes place by the extremely slow process of being first woven into the insensible inner energy of atomic construction and being then subsequently released by radioactive processes.

The inner energy of an atom is perpetually self renewed. It forms a closed circuit or it is separated from the energy ordinarily considered, by a discrete degree. It is set apart and can not be tampered with.

That energy is continually returning into this hidden entropic mode of manifestation which gives rise to an atomic formation in which the inner energy remains equally hidden, is demonstrated by the argument that otherwise the indefinitely extended celestial spaces must shine unless the enormous energy which they contain ceases to function as radiation.*

The necessity pointed out by Maxwell (*Cf. ante,* p. 114) that light must be a *process* is admitted. How then, it may be asked, can Swedenborg's theory of light-*particles* be true? The answer is that Swedenborg's particles of light are not to be confounded with Newton's which, like his atoms, were supposed to be hard, round, indestructible, *material* bodies without organization. The light-bearing ether-particles recognized by Swedenborg, are not such, but are organized by motion out of the aura, and when they are absorbed and converted into thermal energy, the luminous process disappears, for *these* particles are by their very nature themselves a process in the aura.

THE AURA

The necessity for an aura, a medium distinct from the ether, even though the latter must interpenetrate it, a medium out of which the ether is formed and one having probably a structure of its own, is forced upon our attention. To serve as a medium of gravitational force, the aura must have isotropic properties. A few distinctions between light, electricity, magnetism, and gravitation may be mentioned:

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* See F. W. Very, "What Becomes of the Light of the Stars?" (page 298). The argument is this: Somewhere, if light is indestructible, every light ray must meet an obstacle. Even between us and the nearer stars of the Galaxy, there are many dark patches of absorbent material. If the obstructing particle is a reflector, the light is turned backward, and if there is absorption the particle is heated. In time the entire celestial vault must glow more and more. For space would be like a closed vessel with nonconducting walls in which the volume-energy of enclosed radiation would continually accumulate.

Light, or electric-magnetic wave-motion, is sometimes polarized, and then has its movements oriented in a certain *plane.*

Magnetism is never otherwise than a vortical flow permanently polarized about a *line,* which is a magnetic line of force.

But gravitation is absolutely symmetrical * around *points* which are centers af attraction.

Here is an obvious progression.

The vortex-units of ponderable matter attract each other indiscriminately. There is no "caste" here—no classes of atoms which are gravitationally inert or repellent. This seems to result from an absolutely isotropic property of the gravitational atmosphere, or aura.

The ether loses some of its isotropism in the vicinity of ponderable matter, hence it seems improbable that the ether is the fundamental medium and Swedenborg, however he received the idea, was at any rate, the first to assert that the ether does not fill all space. Electric charges, or special distributions of electrons and their limited ethereal atmospheres, attract or repel each other; and by transfer and accumulation, this interaction is more powerful than that of the pulsating vortex-atom condition of matter made out of the aura on which gravitation depends. All ponderable bodies can be electrified, but distinctions begin to appear, especially in the division of substances into an electrochemical series—positive at one end, negative at the other.

Magnetic changes act still more powerfully and are yet more highly specialized, since of the two groups of ferroagnetic and diamagnetic substances, but few show any arked effects. Practically iron is the magnetic substance, nd here the most powerful Jamin magnet can lift nearly en times its own weight, while its gravitational attraction s but an exceedingly minute fraction of the weight.

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* A gravitational field of force is along a straight line joining the centers of gravity of two attracting bodies. This singularity of the resultant force in no wise invalidates the absolute symmetry of the gravitational pressure around each unit of mass.

The direction of elctrical and magnetic forces can be uided by suitable conductors, and they can be concentrated t a particular spot, or their progression can be retarded; ut no one has ever retarded the speed of gravitation or ltered the direction of its attraction.

Hence, while light can be transmitted by the ether-strucure of the universal atmosphere, gravitation which acts vith a speed far greater than that of light even as light noves far more rapidly than the movement of the wind, eems to require a mechanism in the medium distinct from hat appertaining to the luminous vibration, and this mehanism is evidently the more fundamental one, or the aura s within the ether, even as both ether and aura are contructively within the particles of the air.

Reynolds' idea may still be partly true. For example, if he electrons are portions of the universal atmosphere reolving with enormous velocity, they may expand into thin hells pressing back the surrounding relatively quiescent ura, and inclosing a volume of the rarefied medium and his appears to have been Swedenborg's conception; but the ortical granules of the aura by which the gravitational tresses are transmitted must rotate far more swiftly than he ether-structures which transmit light. Hence it apears probable that the units of the aura, besides being disinct as to the form of their motion, are also of a totally ifferent order of magnitude. In about the proportion in hich a raindrop is smaller than an earth, so is an atom maller than a raindrop, and so may a granule of the aura be smaller than an atom, the ether structure, or mechanisn of light-transportation and the electron from which th etherion starts, being of intermediate magnitude.

Swedenborg's early conception was that nature is a mechanism. The idea is only partly true, as he afterward learned; for the mechanical motions of the physical universe have to be accompanied by spiritual forces whicl are directive. The interaction of the two perpetually weave the warp and woof of nature's wonderful garment, as th shuttles of creation ply to and fro in ceaseless play. All i life and activity, but we have not seen the whole proces until spiritual vision is added to the sight of the body.

THE CONSERVATION OF ENERGY IN RELATION TO ETERNAL LIF

The law of the conservation of energy may be only approximately true, if we consider nothing but the materia world, since portions of physicial energy are continuall being set apart to serve as the basis for higher forms o spiritual activity. Swedenborg's doctrine of the limbu needs to be considered here.

Even on the purely material plane of existence the doctrine of the conservation of energy is not as simple as i sometimes supposed. A beam distorted by a heavy weigh can not remain bent forever. It loses the internal structur which gives it elasticity and finally breaks. Every piece o mechanism wears out after a certain amount of use. W sometimes speak of a "permanent magnet"; but unless wor is expended occasionally in restoring its magnetic status the strength of such a magnet deteriorates. There is n evidence that those wonderful pieces of mechanism, th atoms, will endure forever, although they are, with on exception, the nearest approach to a perpetual gyratio which the physical universe can furnish. Only the greate odies of the starry system show changes so slow that they nay, in ordinary parlance, be called permanent and even hese are not absolutely permanent. My suggestion that toms are destroyed in solar centers and reborn elsewhere, vas at first received as though it were a denial of conser-ation, although it merely presupposes an extension of the octrine.* The discovery of radium and its disintegration as now demonstrated that there are unstable atoms even n the earth. The slow evolution of matter appears to be apable of providing suns with sustenance through indefi-te eras. The minute structures may pass away, new ones nay take their places, but the resultant aggregate which we all the universe, or cosmos, must persist. The transitori-ess of all things mundane points to a law of perpetual hange and development.

> "The old order changeth, yielding place to new,
> And God fulfils himself in many ways."

We are not made to live forever in a natural world. There omes a time in the development of a soul when it longs o soar, and feels the weight of earthly thought and earthly ares as an impediment. Yet we shall always retain a onnection with earth-life through that precious gift which ve receive from our mothers—that inmost covering or lothing of the spiritual principle, called the limbus. In hat intermediate state which is between spirit and matter, piritual heat, which is love, and the purest substances of ature commingle their energies in life-forms which fix r perpetuate the individual.

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* See my paper on "The Wasting of Stellar Substance," in cientia for April, 1920.

GENERAL CONCLUSIONS FROM SWEDENBORG'S SCIENTIFI PHILOSOPHY IN RESPECT TO HEAT AND LIGHT

The doctrine of heat and light touches the very inmo of matter and its origin,—it touches also the sun which the great source of heat and light. We are led from our experience of Swedenborg's phraseology to infer peculiar and fuller significance than that of common usa in his terms "light" and "heat" as applied to the natu world; and I think that this inference is amply sustain by the passages quoted at the outset. It is true, that the are passages where these words appear to have only th ordinary meaning. Thus, in *The Canons of the N Church* (Part I, Chapter 6, No. 2) we read: "that these two, namely, heat and light, the world subsists, a every year all things are created upon its surface; and th if these two were withdrawn, the world would fall in chaos, and thus into nothing," where it is evident that t "world" spoken of, on whose surface all things are creat "*every year,*" is not so much the globe beneath our feet that world of organic life, the vegetable and animal kin doms, and that other "world" of atmospheric and ocean fluctuations, whose seasonal episodes obey the comma of their natural ruler, the sun. Here, heat might mean on the life-giving warmth or temperature of the atmosphe and its dependents; but in *True Christian Religion* (n. 7 we read of the creation of the three natural atmospher from the sun of our world "by means of heat and light," and finally of the creation through these of the terraqueous globe with its earthly substances, as well as its forms of life. Here it is evident that a wider influence is attributed to the sun's heat and light, since by means of them the atmospheres have been formed. Although Swedenborg appears to have partially receded from the geometrical doctrine of the *Principia* with its metaphysical terminology in a few passages in his later writings, nevertheless, he has retained some of his former definitions, many of which are strikingly conformable to modern scientific doctrine. His natural "point" must not be taken too literally, even though he speaks of it as analogous to the geometer's point. It is defined as "a simple entity" . . . "produced immediately from the Infinite"; and as "pure and total motion, a motion which can not be conceived according to any law of geometry" (we recall that the non-Euclidean geometry had not then been inaugurated). Yet in this motion there is "nothing substantial," because "there is in the Infinite nothing substantial to be modified." Here the meaning will be better expressed if we substitute *material* in place of *substantial*. In his later writings Swedenborg is everywhere consistent in teaching that the Divine is substance itself out of which all things, both spiritual and natural, are made; and that the universe is held in existence by a perpetual inbreathing of life from the Divine. Hence, since the natural point is said to have position in space without extension, and to be a "conatus," or energy "tending to actual motion," it appears that the point is conceived to be something intermediate between the spiritual and the natural; and as such I think we must concede that it has a real existence, since the most profound natural philosophy has recognized that the material universe is composed of innumerable centers of energy; or as a scientific writer in The Nation for January 18, 1906, puts it in speaking of radium and radio-activity: "Of all these, the last promises to mark the deepest revolution of scientific conceptions, by reducing matter from the rank of primordial substance to that of a special state of electricity. After that we shall be prepared for anything, even for experimental demonstration of the doctrine that electricity is a psychical phenomenon." Jesting aside, however, it will be recognized by students of Swedenborg's philosophy, that the doctrine of discrete degrees has forever bridged the gulf between idealism and realism.

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* It is hardly correct to speak of the universal atmosphe as created "from the sun of our world" because this atmosphe existed long before our sun did; but the germs of atomic str tures in that general atmosphere may, indeed, be created throu reception of light from many suns.

The philosophy of points and their motions may be useful as a means of approximating to truths which it can not explain. Osborne Reynolds' generalization of mechanical theories may not be a demonstration that nature is purely mechanical, but it aids the mental conception of possible arrangements of natural forms.

Among the modern discoveries or theories foreshadowed in the *Principia,* we find the identification of lightning and electricity with a special motion of the ether. It is called a "gyration" and its excitation is attributed to a tremulation of the parts of dense matter. The ether is considered to be made up of spherical particles, capable of great expansion or contraction. These ether particles of varying density mutually press upon each other and upon the interior parts of dense substances. Light, as well as electricity, "depends upon the tremulation of the small and subtle parts of a body," affecting only the ether. Heat is a most intense motion of the parts within the molecules of ether or of air; and movements of the aerial molecules themselves result, which simulate the movement of heat within. Two kinds of heat are distinguished, namely; the internal movement of the ether particles, that is, of their central active elementaries, which we may now identify with the electrons, creating "subtle *elementary* fire,"—such "fire" as we see in the electric arc, brush discharge, and spark,—and the corresponding motion within the particles of the air, producing common or "atmospheric fire." We still make this distinction. The "fire" of the sun is electrically produced incandescence and is distinct from the fire of combustion.

The little work *On the Intercourse Between the Soul and the Body* (n. 16) hints at a further extension of the series. There are "three atmospheres discretely distinct according to the degree of altitude, both in the spiritual world and in the natural world, because each world has its sun; but the atmospheres of the spiritual world ,by virtue of their origin, are substantial; and the atmospheres of the natural world, by virtue of their origin, are material; and forasmuch as the atmospheres descend from their origins according to those degrees, and are the continents and, as it were, promoting vehicles of light and heat, it follows that there are *three degrees of light and heat*." Here, of course the terms, light and heat are used in a specially wide sense, as denoting emanating and internally active, or constituent energy, and not merely the activities of atoms and molecules.

The atmosphere, Swedenborg elsewhere identifies with the aura whose vortical whirls are aroused by every motion of the ether and to a minute extent by the movements of the least parts of gross matter.

The ether-particles have motions of their own, but since they are formed out of the aura, they share whatever general motions it may have, even as man has independent life, yet is carried along in the stream of the Divine Providence. While attached to matter, the ether shares its motion; but as soon as the etherions are flung off as light-quanta, they become independent of matter and have a velocity determined solely by their relation to the aura, which relation i constant, save when the vibrant ether-particles are passin through a body of dense ether attached to matter. Thi temporarily slows down the motion of advance; but th original velocity is resumed as soon as the particles emerg again into the free aura. Any oscillations imparted to th etherions are, indeed, preserved, but these are independen of the velocity of onward progression through the aura The case is this:

If light be emitted with a velocity c from a luminous body (A) which is moving towards an observer at O with a velocity v, and if n oscillations of the ether-particles are made in one second, then, when after 1 second the luminous body has arrived at A with $AA = v$, there will have been crowded into a space $AB = c - v$ (measured towards the observer) the number n of waves, and the length of these waves, when they pass the observer at O, will have been shortened. Observation proves that this "Doppler effect" is a fact.

Now it might be imagined, were it not for this observation, that the velocity v would be added to c, just as the velocity with which a ball is thrown from a moving car in the direction of its motion is added to that of the car; and that thus the velocity of light would be increased by the motion of the luminous body, and that the effect in question would not take place. But the effect is found, and the explanation to which we are led by the constancy of the velocity of light in vacuum and the reality of the Doppler effect is this:

The particles of the ether are themselves formed out of the aura and share any proper motion of translation which it may have. The etherions and their wave-motion (oscillations) are emitted into an aural medium which is relatively at rest in respect to the light. The velocity of light in the free aura can not be changed unless the general motion of the aura itself changes, and the phases of the magnetic oscillations imparted to the aura by the transiting etherion depend upon the period of time which has elapsed, and not upon the distance traveled. It would not have been easy to foresee these things. They rest upon the evidence of experience and the view here presented would not have been admitted until quite recently; but all of these things are entirely compatible with Swedenborg's theory of light.

Swedenborg's favorite doctrine, that nature is the same in her least as in her greatest things, obviously pointed out by the continual recurrence of the spherical form in successive orders of magnitude, probably suggested to him that the particles of the aura are like the greater vortices which they produce around every magnet. There certainly seems to be some ground for this doctrine of similars in the ascending scale of magnitudes, provided we do not make the "similars" into identities on a different scale. The Earth and the sun are gigantic magnets, the one with its polar sheaves of coronal filaments, vortically disposed; the other with its latitudinally eccentric belts of auroral streamers, concentric with the Earth's magnetic poles; while the non-gaseous nebulae are cosmical vortices on the grandest scale.

Light, however, though wonderfully varied in the form and periodicity of its vibrations, is confined to particles of a single minute size, and is said (in *Apocalypse Explained,* n. 1206) to modify substances as to their individual or single things, according to the form in which the individual is from creation, which, when transformed in the light of modern spectroscopic discoveries may be thus stated: Every electron, atom, or molecule of matter vibrates luminously after a fashion peculiar to itself, depending upon the structure or disposition of the parts of the molecule, atoms, or electronic orbit; and each of these vibrations, when transferred to the ether which is capable of receiving the impression of every variety of periodic movement of an electronmagnetic character, constitutes a special form of light, an individual light-quantum, or light particle, containing only those waves whose frequencies agree with those of the source. If now the sequence is reversed, and white light which contains waves of every kind, is permitted to fall upon the same material particles, the light excites in them precisely the same selected vibrations which they would exhibit if made luminously active by any other process, because they can dance to no other tune.

Swedenborg's definition of "modification" can be gathered from the *Principia* (Part 1, Chapter 2, Article 4), where he says: "Rational philosophy will not admit that anything can be or exist without a mode; and since a mode in things limited and finited or in things physical, consists solely in the variation of limits, it therefore follows that nothing can exist without motion," from which it is plain that the term applies to the movements and changes of form of those limited portions of physical substance which we call electrons, atoms and molecules. We are now of the opinion that light is only produced by the motion of these entities. The movements included under the term "modification" are changes in the form of the bounding surfaces of the particles, or in the arrangement of constituent particles.

On the other hand, in *Principia*, Part I, Chapter 3, n. 15, we learn that "in internal motion alone consist the power and quality of producing sequents into act," and in *Apocalypse Explained*, n. 1206, it is said that *heat* actuates and "spreads" (or expands) "the individual (parts), and produces a power (or force) of acting and of effecting according to the form of those (parts), by actuating the *conatus* . . . in nature's least forms," which is "from the spiritual that acts in them and into them." Here, we have a definition of heat which satisfies the demand of modern science for an energy which is something more than that of a "molecular bombardment." Heat, according to Swedenborg, actuates the "*volumes*" of elementary finited space from within. "Thus, the first motion comes from the most subtle, and proceeds gradually to the more and more compounded" (*Principia,* Part I, Chapter 5, n: 29). On the contrary, *light* is an affair of transference of energy at a *surface.*

For "conatus," we may now substitute the modern term "energy," or, to be more precise, we should say "action," since Planck's "energy quantum" was given as $h = 6.55 \times 10^{-27}$ erg *seconds,* or in terms of work, just as the engineer expresses his power as so many horse-power hours. However, if we agree to state all times in terms of one unit for example, the second, we may omit the time, but only with this explicit understanding. A distinction is to be observed between energy and motion. The one is essentially spiritual, productive, real; the other, natural, apparent, and derived. The potential energy of gravitating bodies, is a constant fact, whether obvious motion result from it or not. Gravitation, since it acts almost instantaneously everywhere, must be in space, and yet almost without either space or time; and hence it is an approach to that spiritual reality which is neither matter nor motion, but the *cause* of all material existence. Swedenborg says that heat and light are not material. Here he is apparently distinguishing them from the gross matter with which they are connected, and from those lower forms of activity, molecular and atomic vibrations, which simulate in their outward manifestation the more perfect activities within. May we not then assume that his "third degree of heat" is the most exalted form of activity in nature? And, if so, may we not, without accepting all of the metaphysics of the *Principia*, identify it with the essential activity of the universal atmosphere, the vortical or magnetic element, out of which the others have been formed and which is the first recipient of spiritual influx? Since heat is that which "actuates," or renders active the "conatus," or energy, which in itself is spiritual, there is a powerful argument in favor of this view in the certain permanence of energy, which in this respect exceeds the duration of individual material particles; for the only law of pure motion which mathematicians have found, exhibiting the characteristic of permanence, is that expressing a vortex.

The highest degree of heat is, then, the vortical of the first derivative of spiritual substance, and, in its inmost, is not material. Matter is the vortical compounding of the aura and the electric ether by successive infoldings; and light originates in the fluctuation of the outward form of matter by which the inner activity of its heat is communicated to the surrounding medium.

That which is the signature of the external of one degree, becomes the signature of the internal of the next lower discrete degree (as in the relationship of good and truth in the celestial, spiritual, and natural degrees of human life). The world of matter illustrates this. As love draws all hearts together, love must stand in the relation of spiritual cause to that universal attribute of matter, gravitation. The inmost essence of the most universal force is love. But love has to proceed out of itself to accomplish its purposes. There must be distributing as well as aggregating forces. There must be the truth which separates and analyses, as well as the love which draws, else there were no variety to perfect the unity. The inmost attractive aura, the most potent and universal of the atmospheres in which all of its tremendous gravitative force of the aura resides, must therefore, be involved, inclosed, encompassed, as it were, by a shell, and be so transformed that its outward manifestation is that of repulsion—the characteristic of ethereal or electric particles.

But the process can not end in a single infolding.

> "In love all things begin and end;
> Through love, man doth to God ascend,
> And talk with Him as friend with friend."

The ethereal evolution of the atoms of matter in its ultimate degree is hinted at in the revelations of chemistry as I have suggested, the ethereal evolution of matter may be the imparting of a special structure to the universal medium through the action of light. Physics affirms the development of attraction out of the movements of the repellent electrons, and thus indicates the possibility of this further transformation or involution of the ethereal to form the aerial (gaseous) particle, that which was external in the former becoming latent within the latter.

Reversing the sequence, we see a continual progressive increase of energy in passing from masses of matter to their molecules, from molecules to atoms, from atoms to electrons, until it seems as if, in the inmost recesses of natural substances, there is an approach to an infinite energy —the Divine Power, mercifully veiled by successive limitations, and adapted to uses for feeble finite recipients. As knowledge increases, we are permitted to utilize more and more of this inexhaustible energy. The age of steam gives place to the age of electric power. Miracle no longer means for us the accomplishment of the impossible, but rather that all things are possible to him who has rational faith.

To one who sees the existence of tremendous disruptive forces latent in ordinary matter, the overthrow of a mountain by the aid of Divine Truth may be as much a physical possibility as its spiritual counterpart, the conquest of evil. Thus do we ascend to God from whom we have departed. Thus, only, by the overthrow and inversion of our own life, can we be released from the chains that bind us.

SECTION G

SUMMARY OF CHAPTER VI ON HEAT AND LIGHT

Swedenborg says that "all things were created by the Lord through the Sun of the Spiritual world, not through the sun of the natural world." The necessity of this "Sun of the spiritual world" is not yet acknowledged by science, because Swedenborg's testimony has been rejected. There is thus a profound gulf between the two bodies of doctrine. Natural science either omits, or only vaguely acknowledges the most important knowledge of all; but on the lower plane of the knowledge of nature, present-day science can furnish much corroboration of Swedenborg's thought, and can supplement and correct some of his imperfect statements of natural fact. It is wholly incompetent to touch his deeper wisdom and must eventually sit at his feet in all humility, before its own shortcomings can be acknowledged. The important function which he assigns to natural heat and light is corroborated. The vivification of both the natural and the spiritual worlds by spiritual heat and light from the spiritual Sun is only dimly apprehended.

Section A. Summing the evidence for correlation in Section A, Swedenborg associates heat and light, but does so on account of their obvious relationships, in that a sufficiently hot body radiates light, thereby becoming cooled, that is, by the act of radiation the heat is converted into light; and conversely, a sufficient condensation of sunlight, by a lens, or by a concave mirror, will generate combustion and heat.

Clausius, in treating of the correlation of forces, permitted himself to speak of heat as a molecular vibration and of light as an ethereal vibration, and to virtually unite or identify the two; but in this laxity of definition, he obscured the fact that heat and light are very different modes of the manifestation of the *one* only *energy* which underlies them both. Swedenborg was careful to preserve this distinction, and Clausius was not unaware of it; yet he spoke of the essential identity of luminous and invisible radiations as if it involved an identity of light and heat,—which is not correct. This vagueness and inaccuracy in the use of terms has led to much misapprehension of the true scientific doctrine, to which I have returned in a later section of this chapter.

In continuing his treatment of the subject of correlation, Clausius reduced magnetism and electricity to a single agent —electricity—thereby virtually ignoring the more universal element which underlies the electric one. Swedenborg's apprehension of this relation is at bottom a truly philosophical one and corrects this misapprehension, yet, unfortunately, his lengthy descriptions are far from clear and require modification. Admitting this, it is nevertheless true that Swedenborg's conception of discrete degrees of atmosphere supplies the basis for a correlation which is not one of *identity* but of *successive derivation.* The correlation is that of the motions in diverse media.

Swedenborg had the idea that both light and electricity are produced by a tremulation of the ether. Clausius went further and held that the atmosphere of so-called "ether" which fills all space and which, he supposed, conveys the luminous vibrations, is an atmosphere of electricity. Neither of these ideas is correct, and yet we are being led to see that there is a very close connection between ether and electricity. Bragg at one time suggested their interconvertibility. Swedenborg was close on the track of the real nature of the connection between the two, when he described his "first element," which is the needed "missing link."

Back of electricity and back of the ether is the universal atmosphere. We have touched upon the question whether or not it has the property of mass, and have concluded that it is without mass and therefore does not attract gravitationally. Nor does the vibrating ether possess more than a small fraction of the mass of the electricity with which it is associated.

We have seen that Swedenborg associated electricity with a "tremulation" of minute corpuscles, and that Bourdin, in his controversy with Clausius, ignored the discrete separation of ether and air and sought to explain electricity as a vibratory motion of ordinary matter. Clausius in reply showed that if the universal medium had a pressure of only 1/1,000,000 of an atmosphere, its particles would be as far apart as a wave-length of ultra-violet light. But the particles must be still farther apart and the pressure very much less, in order that the medium may not interfere with the freedom of planetary motion. And he clinches his argument by pointing out that it is inconceivable that a *transverse* vibration can be propagated through a medium whose particles are farther apart than the wave-length of the luminous vibrations. Swedenborg's electric "tremulations" were not described explicitly, and so he did not lay himself open to the refutation which Clausius gave to Bourdin's hypothesis.

But, on the other hand, it is highly probable and indeed almost certain that the electron has a *pulsatory* motion similar to that of the pulsating drums in the hydro-dynamic experiments of Bjerknes, and this sort of motion which is distinctly recognized by Swedenborg, though he does not attribute it explicitly to an electric substance, appertains both to the electron and to the light-bearing ether-particle.

Finally, the recent extension of the doctrine of correlation to include matter and energy, is a verification of one of Swedenborg's positions; and the momentous discovery, by Weber and Kohlrausch, of an electric explanation of the fact that the ether-particle travels with a velocity of 3×10^{10} cm./sec. completes the unification of the physical forces.

Section B. In Section B the modern kinetic theory of gases is analyzed. Boyle's law of the inverse proportionality of volume to pressure in gases is known to require corrections which transform the law into Van der Waal's equation. The corrections are found to conform to the explanation that the molecules of a gas have dimensions which are relatively small in comparison with the space which separates them, that they are in constant motion, collide, are deformed and, by their elastic restitution, have their motions reversed. By summation, the elastic pressure of these reversals is transferred to the walls of a containing vessel, and the energy involved in the motion is what we call heat.

That the gaseous particles occupy only a small portion of the space which they are supposed to fill, is further indicated by the fact that several different liquids can evaporate into a closed space and produce their individual maximum vapor-pressures at the given temperature, precisely as if the space were empty. The different molecules interpenetrate without interfering, unless their number becomes very great. Objections to the theory which have been urged by Hirn, have all been met. This therefore overthrows Swedenborg's doctrine that the particles of air are expanded by heat and are always in most intimate contact. The constitutive internal motions within the atoms are enormously more powerful than any increment of internal motion produced by heat. The relatively small thermal increment of internal motion is not competent to produce by its centrifugal pressure, except in rare cases where, by some rearrangement of parts, it constitutes the formation of an allotropic variety of the element.

Swedenborg's doctrine that atmospheric heat is solely due to the central motion of the air-particles and that this is what produces their expansion, and by derivation that of the entire volume, is also abrogated by the fact that the two specific heats of a mass should be equal on this supposition, which is never the case.

While Swedenborg's thermally expansible air-particle must be abandoned in favor of a kinetically vibrating and interpenetrating swarm of particles, his reiterated emphasis of the part which an underlying *conatus* plays in thermal activity, is sustained by the philosophic discussion which Hirn has contributed to this problem.

Hirn points out that a majority of physical transformations involve a display of energy which is akin to the human will. He thinks that we have not explained what energy is and can not explain it, but can only follow the modes and motions in which energy is manifested. This may be true in respect to the discrete degree between spirit and matter, but the further study of internal forms of motion within atoms and electrons, and above all the study of that universal aura which is the abode of energy, may be trusted to give a deeper insight in regard to heat and light.

Section C. Modern electromagnetic theory has made some progress in the works of Maxwell, Hertz, Lodge, J. J. Thomson and Oliver Heaviside, towards an elucidation of the problems of the aura. But the *starting point* in all investigations of nature must lie in that intermediate realm between spirit and matter wherein energy resides.

Swedenborg's doctrine of energy discoursed of nature in its embryonic stages; nor can modern science do any better. The mathematical treatment of the doctrine of energy is wholly a symbolic one. In the place of philosophic symbols, we bring algebraic ones, but no one need be overawed by the imposing array of mathematics into supposing that these symbols involve anything more than a convenient mode of expressing our surmises in regard to the meaning of facts which frequently lie just over the border of complete experimental knowledge. Here the extraordinary experience of Swedenborg on both sides of the veil which separates the natural from the spiritual world, is most needed.

Swedenborg's conception of particles formed by perpetually spiral, or vortical motion, under the guidance of energy, has proved to be the key to the nature of matter.

The inmost untransformable energy of matter is undoubtedly what Swedenborg means by his "third degree" of heat. "As the atmospheres descend from their origins according to these [discrete] degrees; and as they are the containants of heat and light, and, as it were the vehicles by which they are conveyed, it follows that there are three degrees of light and heat; and as the light in the spiritual world in its essence is wisdom, and the heat there in its essence is love . . . it follows that there are three degrees of wisdom and three degrees of love, and therefore three degrees of life." (*Influx*, n. 16.)

In agreement with present science, Swedenborg conceived of heat in matter as activity exerted indiscriminately throughout an entire volume. We define heat as so much mechanical energy *per unit volume.* But light which is produced by the transformation of heat into ethereal radiant energy *at a surface,* is composed of innumerable diverse sorts of luminous vibrations. The distinction, as Swedenborg points out, is one of the *form* of the least parts of the ensuing activity. As Brewster well said, there are infinite things in the solar spectrum. But natural heat is one unidentifiable energy, wherever it may be found. The distinction between the two should be scrupulously preserved.

Swedenborg supposed that there may be such a thing as "cold light," which is true in a way, since the light emitted by the firefly, if it were accompanied by the enormously greater invisible radiation which is found with similar light from flames or from incandescent solids, would burn up the insect. But the isolated luminous beam is nevertheless produced at the expense of thermal energy in the body of the creature and can be reconverted into heat, as can every other sort of light. The *Principia* contains some unjustifiable speculation as to the absence of internal revolution in the particles producing this supposed "cold light." It is not an absence of heat, but an exceptional circumscribing of the mode of luminous vibration which characterizes the firefly's light.

A further speculation as to heat being an increased revolution within the least particles of matter, or a "central" motion, was no doubt imagined in order to account for the supposed enlargement of the particles in thermally expanded air, necessity for which is abrogated by the abandonment of this hypothesis as described in Section B. All that remains of the supposition is that heat involves internal motion in the larger masses, and that a portion of this motion is exhibited in a trifling increase of the normal rotation within the atoms, etc.

We must reject the placing of the order of magnitude of the ether-particle two removes from that of the "first elementary" vortical particle, or electron, because the two have a very close affinity and agreement in their dimensions. Also, of the two statements: (1) that "a particle of water is similar to a compressed particle of air"; and (2) that the particle of aqueous vapor is a "fifth element," much larger than an air-particle;—which are discrepant, we may now definitely subscribe to the first and reject the second, together with the speculations in regard to the puffing out of the particles of water by an infilling of ether, when the water is converted into steam. Instead of this, we now recognize that the expansion of steam is due to an increase of the thermal translatory velocity of the water-particles.

Swedenborg's assertion that there are three discrete degrees light, requires interpretation. We may perhaps assign it to the three orders of spectra: Continuous spectra which arise from the thermal vibration of matter in large masses, usually either solid or liquid; band-spectra, produced by the vibration of the atoms within the molecules; and line-spectra, coming from perturbations of the electrons within the atoms. The three-fold constitution of matter which is formed out of aurions, electrons, and atoms, presupposes a three-fold internal energy, or three degrees of heat. But the ether is unique. There are not three different sorts of light-bearing particles, although the properties of the ether involve those of the aura out of which the ether is formed, and it has relations with both matter and aura.

Scientific speculations about the luminiferous ether have hitherto failed to distinguish it from the aura and require revision.

The aura is capable of transmitting longitudinal gravitational pulsatory waves, and has great capacity for storing energy, which it receives from the vibrant ether and in turn communicates to incipient matter. The aura, which conveys to matter the property of inertia by the resistance which it opposes to any change in material motion, must itself have an "inertia" of its own in order that its particles may ceaselessly rotate. The intermediate ether (associated with both matter and the aura) exhibits something analogous to friction, giving luminous retardation and refraction, together with other properties, such as elasticity, of which Swedenborg says that it is so perfect that it can adapt itself to any form of motion. For the origin of this elasticity, however, something more fundamental than the ether is necessary.

Section D. Matter has both an electrical and a thermal composition. The former is well on its way to solution through the revelations of internal structure of atoms given by line-spectra. The electrical properties and the masses of the atoms are explicable if we suppose that they contain alternate concentric shells of positive and negative electrons, revolving in opposite directions, with a few supernumeraries. The thermal properties suggest that the electric whirls, in addition to possessing a potential thermal energy of revolution by virtue of their mass-motion, are enclosed within a thermal atmosphere, or vortex-aggregate of aura, something after the sort imagined by Hicks, which coördinates their motion and gives it permanence. Mathematics, however, which deals with point-sources and sinks of motion, with irrotational media, and even with imaginary quantities, finds itself at a loss when required to produce a scheme of a physical mechanism which can fulfil all of the seemingly irreconcilable proclivities.

The indications now point to a derivation of the chemical elements from hydrogen or at least from a small number of light elements which are multiples of this element. Organic hydrogen radicles exhibit polymerization and periodicity in their properties resembling that of the elements. At critical temperatures, polymerization is reversed. Dr. Mills assigns this as a principal cause for the light-changes in some of the variable stars.

The fusion temperatures of the elements exhibit strong periodicity in accordance with the hypothesis of a variation in atomic volumes from accessions of new electronic shells. In general, the heavier metals have the least power to spare, the least heat to dispose of. Their energy of formation has become latent. The vortex imagined by Hicks, which represents these facts, resembles the primitive vortex-particle described by Swedenborg, except that the later stopped at a first limit, whereas the recurrent thermal periodicities of the chemical elements suggest that there are multiple vortex-aggregates.

Carnelley also found evidence that a definite quantity of thermal energy successively appears and disappears in the transformation of one element into another.

Emerson Reynolds and Crookes likened the evolution of the elements to the dying oscillations of a compound pendulum, for the lighter elements are the most vigorous ones; which reminds us that "it is evil which makes weight in the spiritual sense;" and as the heaviest atoms are unstable, there is here a representation of the merciful law of Divine order by which evil has within it the germs of its own destruction. The lightest elements are the only ones which can be used in the construction of living organic forms.

J. J. Thomson's discovery of the compound nature of the atom and of its formation by the aggregation of electrons, was the first confirmation of Swedenborg's doctrine of elementary particles. Dr. Vegard's interesting hypothesis of the arrangement of the limited number of "Moseley" electrons in spaced revolving rings, explains the X-ray spectra of the elements. My hypothesis of paired, revolving, spherical shells of equivalent positive and negative electrons explains the atomic mass, while at the same time providing a reason for the arrangement of the supernumeraries. And if we add a second series of electrons equal to the Moseley number and arranged at the corners of concentric cubes, as Lewis and Langmuir suppose from indications given by chemical reactions, we have *three* distinct systems of electrons in every atom.

A regrouping of Mendeléeff's periods gives a classification of the elements in *three* paired "cycles" of increasing complexity, containing 4^2, 6^2, and 8^2 elements, at least these numbers would be found if each group were complete; but the heaviest group has many gaps, owing to instability.

Swedenborg taught that the least particles of iron are magnets and that their magnetic quality is due to an internal revolution, or to a higher discrete "degree" of heat. The Zeeman effect reveals a magnetic influence on the internal revolution of the electrons within the atoms, and confirms the existence of internal magnetism within the atoms.

Swan's stress-effects of electrification on resin have given suggestions as to a probable vortex-structure in the electron, which I have used as a basis for my hypothesis that there is but one electron which has indrawing and outflowing poles, and which can be either negative or positive according to their presentation. The balanced forces within the atom, demanded by these conceptions, will require for their elucidation a science of atomic mechanics even more complicated than the celestial mechanics of gravitational theory.

Section E. Equilibrium within the atom is maintained by the interaction of electric repulsion and attraction with variation of pressure, depending on the masses and motions of the electrons. Monatomic molecules have only three degrees of freedom, depending on their motion in the three coördinates of space. Molecules composed of two atoms at a fixed distance apart, have two additional degrees of freedom from the revolution of the component atoms about their common center of gravity. If the distance between the atoms within a molecule also varies two more degrees of freedom are acquired.

The thermal properties of matter depend most intimately upon the degrees of freedom in the external motions of their least particles, and so the accomplishment of good works and the love of them require freedom of choice on the part of individual human beings. But there is an internal freedom of the will which is given by the Lord alone and can not be taken away, even though tyrants may chain the lover of freedom in a prison cell. And just so there is an inner freedom of electronic motion within the atom which we can not touch. The highest "degree" of heat, like that of love, is inviolate.

The thermal properties of matter give rise to pressure, and the science of thermodynamics is mainly a study of the crowded molecules of high-pressure steam. But the characteristic *spectra* of the elements are best observed in rarefied matter, because here alone is there sufficient freedom for the full exhibition of the internal luminous motions.

By Bohr's law, the revolution of a single electron about an atomic nucleus, takes place in stable orbits which are harmonically related, somewhat as the planetary orbits are spaced after the law known as Bode's, but much more accurately. There is here confirmation of Swedenborg's assertion that the forms and motions of the least parts of nature are more perfect than those of the grosser bodies.

The degrees of freedom in the atoms have been critically studied by W. F. Magie who finds that the total increase of thermal energy, corresponding to a rise of temperature of one degree in unit mass, can be obtained by adding the number of degrees of external freedom of motion of the molecules to the number of degrees of internal freedom, plus a certain amount of potential energy.

The equipartition of internal energy between kinetic and potential, has been considered probable from theory, but is now demonstrated through the verification of Steigmüller's formula, which can therefore be used to compute the degrees of freedom in solid bodies from their known specific heats. All of this knowledge refers to heat of the lowest discrete degree, which is thermometrically determinable. Besides this heat, as just noted, we have a vastly greater amount related to the hidden internal motions of atomic constitution.

In my "Cosmic Cycle," I suggested that the atoms are evolved out of the universal atmosphere, that the disappearance of an enormous amount of thermal energy is involved in the formation of the atoms and will reappear upon their destruction. This was confirmed when radium was discovered to be thus disintegrating. The breaking up of the radio-active elements is attended by the production of three kinds of rays—α, β, and γ. These are respectively, atoms, electrons, and etherions; and in their trinal order, they suggest that here is a reversal of the mode by which matter has been formed; that, in fact, the rapidly vibrating etherions have been *the origin* of matter, as pointed out in my paper: "What becomes of the Light of the Stars?" The third or inmost degree of heat and of matter, is therefore energy communicated by means of light and subsequently formed into two succeeding degrees which are the electrons and the atoms. The atoms embody still another subordinate trine, shown in the analysis of the positive "canal" rays of electricity and in the trinal emanation from the new star in Perseus of 1901, that is, there are three sorts of generative subatoms.

These things are not shown in Swedenborg's thesis, but I suspect that my eyes were opened to see them through my belief in the reality and importance of the trinal principle which he teaches.

Section F. Molecules are not spheres, but are groups of associated spherical atoms, sometimes symmetrical, but often highly unsymmetrical. These molecular groups exist only in the gaseous and liquid states. In solutions, the dissolved molecules are usually partially dissociated, or ionized, especially if the solvent consists of complex molecules which are easily broken apart, giving constituents which form weak associations with the ions of the solute. Such a solvent is water which readily forms complex and easily disrupted molecules, or "hydrols."

Simple substances have their atoms arranged in layers in normal rectangular piling, when in the solid state; but compounds have alternate layers of different kinds of atoms, variously arranged, and here the more powerful affinity of the added atoms may pull the alternate layers into positions of diagonal piling, or what Swedenborg calls the "fluid quadrilateral pyramidal, or natural" position. This has been verified in several cases, such as that of potassium chloride; and incidentally the computations confirm the supposition that the atoms are spherical. The reality of Swedenborg's conception of a lattice structure of atomic piling in crystals has been verified by the interference pattern of their X-ray spectra.

Swedenborg's hypothesis of elementary particles as being bullular was revived in a modified form by Osborne Reynolds in his "Submechanics of the Universe." Even with the added resources of much new experimental work and a profound mathematical analysis, the hypothesis can hardly be called an unqualified success. An experiment by C. E. S. Phillips, recorded by Lieut. Col. R. de Villamil in his *ABC of Hydrodynamics,* demonstrates an extraordinary and unlooked-for rigidity of a sand-filling in tubes, which seems to overthrow the fundamental idea of the mechanical properties of such a medium as was imagined by Reynolds, supposed to be composed of noncollapsible spherical particles devoid of friction. In this experiment a column of loose sand, confined only by thin paper at the lower end of the metal tube, supported the weight of a man. The pressure was not exerted in all directions, as in fluids, for if it had been, the paper would have burst; but the trifling friction between spherical solid particles diverted the pressure laterally, so that it was wholly transferred to the vertical walls of the tube.

Very much to the point and in admirable agreement with the doctrine of light presented in the *Principia* is Max Planck's analysis of radiant energy and his determination of a least quantity, or *"Wirkungs-quantum"* for light, which is undoubtedly the measure of the energy in one of Swedenborg's ether-particles. To Swedenborg belongs the credit of having given a rational scheme of the structure of this entity. Planck does not attempt to do this, and is noncommital as to the nature of the luminous mechanism; but his light-quantum is in no sense incompatible with the supposition that it is a distinct light-particle, or etherion, formed by motion out of the aura.

This wonderful substance, the aura, is the physical basis of all things in nature. Its perpetuity is a symbol and guaranty of a still wider continuity of existence in a spiritual world of causes. Energy, through its successive states as heat and as light, is continually being dissipated by gross matter and returns into the entropy of the aura, there to be preserved, until it can be reëmbodied.

CHAPTER VII

SWEDENBORG AND PSYCHICAL PHENOMENA

SECTION A. DREAMS

THE word "soul" is used in common parlance with a variety of meanings. Swedenborg also uses it in several different senses. Sometimes he makes it synonymous with spirit—"soul, *or* spirit"—is his expression in *Arcana Coelestia,* n. 444, and elsewhere. In general, soul is predicated of that which is within in which is life. Thus, "as blood constitutes the life of the body, it is its ultimate soul, and may thus be called the corporeal soul, or that in which the corporeal life of man resides." (A. C., n. 1001.) "Soul in the universal sense signifies all life; for in this sense, 'the soul' is that from which another thing is and lives; thus the soul of the body is its spirit, for from this the body lives; but the soul of the spirit is its still more interior life, from which it is wise and understands." (A. C., n. 2930.) Again, "the soul is the very *esse* of man, and the sensitive or corporeal is the *existere* of it" (A. C., n. 2621.) But when associated with heart in the Word of God, the heart signifies the will, and the soul the understanding.

Turning to the "Century Dictionary," we are told that "in biblical and theological usage 'soul' (*nephesh, psyche,* also rendered life) is sometimes used for the noncorporeal nature of man in general, and sometimes, in distinction from *spirit*, for the lower part of this non-corporeal nature, standing in direct communication with the body." This latter appears to be the sense in which the term "soul" is used by the modern psychical researchers, and, if so, it practically coincides with what Swedenborg calls the lower or animal mind (Latin *animus*), which is shared by both men and animals, or possible even with Swedenborg's *limbus,* or intermediate covering of the spirit, formed from the purest substances of nature, but organically a complete duplicate of the inner spiritual organism. Here Swedenborg stands alone among European scientific men, for modern science has heretofore had only the most vague conception as to what the soul is, and, as the "Century Dictionary" tells us, "it is also commonly believed that the soul has no parts," whereas Swedenborg points out in *Arcana Coelestia,* n. 444, that in this case man should have no need of a brain so large and so elaborately organized.

SWEDENBORG AND PSYCHICAL RESEARCH

After enormous labor, our societies for psychical research have determined a few facts in relation to the natural of the spiritual degree, which, though not to be compared with the facts established through Swedenborg's unrivaled experience,* either for range or certainty, are nevertheless of some value as corroborating what he tells us. It is only fair to state that these results of psychical research, conducted blindly in an unseen universe of which the experimenters do not have and do not profess to have any clear conception, raise about as many questions as they settle.

Now Swedenborg teaches that every thought inflows from and is infilled by an affection, and every ultimated affection is clothed by a thought, while the two are united in an act. Love is spiritual substance, and it can be embodied in a form which is real, and under certain circumstances is capable of being exhibited on the plane of natural sense, which is that of the limbus. Something substantia coming down at least to the level of an ethereal emanation or atmosphere, is involved in the numerous psychical experiments to which the name of telepathy, or thought-transference has been given. This is perhaps one of the sures results that has been obtained by psychical-research experiments. In one form of these experiments, simpl drawings, made on paper and gazed at intently by a grou of people in one room, are reproduced with more or les fidelity by sensitives in another room. It seems to be sort of wireless telegraphy, in which human brains play th part of sending and receiving stations and the ether is th medium of communication.

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* In T. C. R., n. 280, we are shown that this unique experience taught even the angels things which they had not before understood, "because there had not been before given the means of comparision, in a man who was in both worlds at once."

Phantoms of newly deceased persons and even message from them are sometimes perceived by distant friends o relatives. This has been abundantly verified through th data collected by our psychical-research societies. Since i is love which unites all who desire to be near each othe and causes spiritual presence in the world of spirits, a stated in Swedenborg's *Heaven and Hell* (n. 194), som of these perceptions of spiritual presence may be receive through the spiritual senses by those who are still o earth and who are united with friends on the othe side of the veil by means of some strong affection held i common. Such perhaps was the following instance: Seate at my desk in the Observatory at Westwood, Massachusetts alone and engaged in writing, but temporarily absorbed i deep thought, I saw standing before me, clothed in beautiful white garments of delicate lace, the figure of a frien in distant Pittsburgh—Mrs. Awl. More than any one else she had been instrumental in bringing together myself an the woman who became my wife. Also she was much interested in the subject of spirit intercourse, and had rea some things from Swedenborg. My wife considered her as perhaps her dearest friend. That afternoon a letter from my wife's brother in Pittsburgh arrived, telling of Mrs. Awl's death. It was her resurrection day. I had not been thinking of her recently, and did not know of her sickness. Here it is conceivable that the impression was a telepathic one, assisted by the letter in transit; but, if so, it is the only time such an impression was received during my waking hours.

DREAMS AND THEIR INTERPRETATION

Of telepathic impressions of the contents of letters, received through the dream-life, while the letter has been in transit and therefore in advance of its receipt, I have had dozens of examples. Such a one is the following: In the night between May 30th and May 31st, 1888, I dreamed that some little girls had turned away from me, and that I was picking up pebbles on the beach, enclosing small spherical concretions, curiously arranged. Among the pebbles I found some pieces of carved wood which seemed to be of great antiquity. Then some of the stones turned to books. I particularly examined one in Naples-yellow covers, printed in German, with interlinear translation. It seemed to be a collection of essays on physical subjects, one of which was illustrated by a colored plate of spectra.

In the afternoon, I received from Professor Langley a letter (mailed in Washington, D. C., May 29th at 8:30 P. M., but not delivered until May 31st at 2:30 P. M.), stating that he proposed "to take the doctrine of radiant energy for [his] discourse at Cleveland" before the American Association for the Advancement of Science, and desiring me to "make notes of anything referring to the early history" of this doctrine, which is intimately connected with the idea of the molecular structure of matter (in my dream typified by the "concretions"); and he particularly referred me to Heller's *Geschichte der Physik,* a German work in Naples-yellow covers, made up of a series of biographical essays, describing the lives and achievements of physicists. I had never examined the book carefully, or I might have guessed it from the dream, for there was no other book in our library which resembled the dream-book so nearly. It is true that the book is not illustrated, but the spectrum seen was suggestive of the subject of study. Neither is the book interlinear, but this, again, conveyed the idea of the translation which I was requested to make. The turning away of the little girls signified that my affections were not especially enlisted, the work being of the nature of drudgery. The antiques among the pebbles meant history, the pebbles themselves meant facts, and the sea-shore, knowledge.

Some might think that this was a direct thought-transference from the mind of the writer of the letter to mine. Against this interpretation, which involves the further translation of the impression into the language of symbolism, it is to be noted that the message was not received at the time the letter was indited, but many hours afterwards, while it was in the mail and approaching me through space. Moreover, it was night time, and the distant writer was probably asleep like myself. The dream-impression from a letter comes so frequently when the letter has nearly reached the receiving station, that one wonders whether the paper and its writing may not serve as a physical basis for an associated spiritual influence. It is as if the go-betweens might be spirits associated with both parties in the transaction, but independent of either, and yet cognizant of the written message. In some cases the connection is even more remote. It appears as though certain spirits were delegated to keep watch over the transmission of an important message. These spirits seem to be kept in touch with the *material* basis of the impression, perceiving somehow a kind of human atmosphere which lingers attached to the paper relic. At least I can not understand in what other way the thing is done. For instance, on a certain occasion a scientific paper, written by me, had been forwarded by the Editor of the Astrophysical Journal at my request to the place of meeting of the American Astronomical Society, where it was to be read in my absence by the Secretary of the Society. While the meeting was being held, I dreamed that I had a gun which hung fire when I wanted to use it to bring down the game. I interpreted this to mean that my paper had not been read and said so in a letter of inquiry, addressed to Secretary Fox. He replied to this effect: "I give you credit as the champion dreamer. You are quite right. Your paper was *not* read, since it was not handed to me in time." Here neither Professor Fox nor I had any knowledge of the mislaying of this paper. It was a mischance, but we could find no one on whom to lay the blame. The spirits did their part. Perhaps I should have telegraphed.

It may be objected to such modes of communication as those here cited from the dream-life, that they depend on symbolic interpretations which are uncertain, and which are therefore not susceptible of accurately scientific verification. Such appears to have been the view of Mr. Frank Podmore in his "Naturalization of the Supernatural" in the following citation: "The impressions by which foreknowledge of the future seems to be conveyed," says Mr. Podmore, "are mostly dreams,—that is, they belong to a class of impressions which we have already recognized as being evidentially so weak as to give but dubious support to telepathy" (p. 345). The mention (p. 95) of "the class of symbolic dreams—a survival of the occult art of the interpretation of dreams," and the statement (p. 348): "One obvious defect in the symbolic dream or omen is that there is no intrinsic relation between the event and its symbol," show that this writer has no knowledge of correspondences. (Cited in my paper: "Current Speculation Concerning Phenomena on the Border Region Between the Natural and the Spiritual Worlds," New-Church Review, October, 1909, p. 501.)

Despite the reluctance of psychical research to admit the dream-evidence, science is often compelled to deal with data which are very imperfect and to supply many "missing links." While such science is not exact, we all recognize the legitimacy of the scientific method as thus applied. Almost the whole of historical geology is founded on a restoration and interpretation of very imperfectly recorded evidence.

Moreover, the symbolic mode of interpretation is by no means a blind one to those who know something of the law of correspondence which binds the spiritual world to the natural one. Dr. Anna Kingsford, in her "Dreams and Dream Stories," narrates the following dream:

THE WONDERFUL SPECTACLES

I was walking alone on the sea-shore. The day was singularly clear and sunny. Inland lay the most beautiful landscape ever seen; and far off were ranges of tall hills, the highest peaks of which were white with glittering snows Along the sands by the sea came towards me a man accoutred as a postman. He gave me a letter. It was from you. It ran thus:—

"I have got hold of the earliest and most precious book extant. It was written before the world began. The text is easy enough to read; but the notes, which are very copious and numerous, are in such minute and obscure characters that I can not make them out. I want you to get for me the spectacles which Swedenborg used to wear; not the smaller pair—those he gave to Hans Christian Andersen—but the large pair, and these seem to have got mislaid. I think they are Spinoza's make. You know he was an optical-glass maker by profession, and the best we have ever had. See if you can get them for me."

When I looked up after reading this letter, I saw the postman hastening away across the sands, and I cried out to him, "Stop! how am I to send the answer? Will you not wait for it?"

He looked around, stopped, and came back to me.

"I have the answer here," he said, tapping his letter-bag, "and I shall deliver it immediately."

"How can you have the answer before I have written it?" I asked. "You are making a mistake."

"No," he said. "In the city from which I come, the replies are all written at the office, and sent out with the letters themselves. Your reply is in my bag."

"Let me see it," I said. He took another letter from his wallet and gave it to me. I opened it, and read, in my own handwriting, this answer, addressed to you:

"The spectacles you want can be bought in London. But you will not be able to use them at once, for they have not been worn for many years, and they sadly want cleaning. This you will not be able to do yourself in London, because t is too dark there to see well, and because your fingers are not small enough to clean them properly. Bring them here to me, and I will do it for you."

I gave this letter back to the postman. He smiled and nodded at me; and I then perceived to my astonishmen that he wore a camel's-hair tunic round his waist. I hac been on the point of addressing him—I know not why— as *Hermes.* But I now saw that he must be John the Baptist; and in my fright at having spoken with so great saint, I awoke.

Dr. Kingsford's dream is filled with genuine significatives. The ancient Greeks spoke of Hermes as the messenger of the Gods, and Swedenborg tells us that the spirit associated with the planet Mercury are indeed the messengers of the universe. They serve as intermediaries to connect distant worlds. "Hermes" can stand for those spirit who act as intermediaries in intercourse between the natura and the spiritual worlds. But John the Baptist, as representing the letter of the Wood, is indeed most truly th means of communication with heaven. The "postman" ha the answer to the letter already in his bag, because there i given, with the significative dream, a perception of its meaning to one who is in illustration. Yet in order to read th writing and especially in order to read that "earliest anc most precious book extant"—God's Holy Word—also written, like the dream, in symbols, we need *Swedenborg' spectacles,* namely, his law of correspondence. The playfu allusion to the optician, Spinoza, appears to be a little asid from the mark. It is true that the philosopher, Spinoz (never mind the natural optician, for it is his services as spiritual optician in illuminating the *mind* of man, whic are here called into requisition) postulated an infinite divin substance of which all things were but attributes and manifestations, in this respect partially presaging Swedenborg' doctrine that the Divine Love is the only substance out o which the universe has been created. But Spinoza formulated no doctrine of significatives, and "Swedenborg's spec tacles" were a direct gift from God. One must not be surprised to find a few incongruities in a dream otherwise rich in significatives. In some dreams every item is symbolic; but usually there are a few unnecessary details—stray rubbish from the Hall of Dreams—which have adhered by chance and color the narrative. The dreams which come during states of severe sickness are apt to contain little else than rubbish. Swedenborg calls them "fantastic dreams." They are induced, he tells us, by deceitful and vicious spirits who are attracted by the disordered state of the body and try to keep it disordered. Nothing useful or instructive can come from spirits and genii of this low order. But the higher spirits and the wise angels can instruct and warn us in dreams. These speak the language of the heavenly world, and the dream is "significative." Occasionally, the Lord Himself sends a "Divine dream," prophetic of things to come and revealing the hearts of men. Such are the dreams recorded in the Word. Even in significative dreams, however, the imagery is such as the angels find ready to their hand in the internal memory of the recipient.

The phenomena of the dream-life, now rather cursorily dismissed by psychical research for lack of that authentic mode of interpretation which Swedenborg has given, deserve our most careful attention, because, in the first place, they are the most universal psychical experiences of all mankind in all ages, testifying to the reality of the spiritual world and to the actuality of an overruling Divine Providence; and, in the second place, because during sleep we are peculiarly under the protection of the Lord and the angels. Hence no harm can come to us from the investigation of communications which are received through dreams, which is not always the case in other modes of intercourse with the departed. Thus the practice of wizardry in former ages was attended by such gross perversions that it had to be forbidden in the Sacred Scriptures, and it is still apt to be more or less disorderly. On the other hand, the dream messages are divinely sanctioned by their inclusion in some of the most touching episodes of sacred history, recorded in The Word.

Swedenborg's first initiation into the life of the spiritual world was a gradual one, ushered in by vivid dreams, some of which he has recorded. He has also given us much light as to the mechanism of dreams. In the *Arcana Coelestia* (nn. 1975-6) we are thus instructed through Swedenborg's experience:

"As to dreams, it is known that the Lord revealed the arcana of Heaven to the prophets, not only by visions, but also by dreams; and that the dreams were just as representative and significative as the visions; and that they were almost all of one kind; and further, that things to come were disclosed by dreams to others as well as the prophets; as by the dreams which Joseph had, and by the dreams of those who were with him in prison, of Pharaoh, Nebuchadnezzar, and others; from which it may be evident, that dreams of this kind, equally with visions, flow-in from Heaven; with this difference, that dreams occur when the Corporeal is asleep, and visions when it is not asleep. How the prophetic dreams, and such as are in the Word flow-in, nay, descend from Heaven, has been shown me to the life."

"There are three kinds of dreams. The first kind come mediately through Heaven from the Lord; such were the prophetic dreams treated of in the Word. The second kind come through Angelic Spirits, especially those who are at the right in front above, where there are paradisiacal things; from this source the men of the Most Ancient Church had their dreams which were instructions. The third kind come through the Spirits who are near when man is asleep, which are also signficative. Fantastic dreams come from a different source."

Because dreams involve intercourse between those who are associated in the natural and spiritual worlds, their complete elucidation required experiments which could be conducted only upon one who could be simultaneously in both worlds. Swedenborg was such a person, and his experience is therefore of immensely more value than the very vague guesswork of the psychical-research societies, concerning dreams, which does not deserve to be called scientific, because it omits some of the necessary data. The following experiment is taken as given in the Potts "Concordance," omitting minor details:

"In order that I might thoroughly know how dreams flow-in, I was put to sleep, and I dreamed that a ship arrived with things of every kind delicious and tasty for eating. The things in the ship were not seen, but were stored up. In the ship stood two armed guards, besides a third who was the master of the ship. The ship passed into a kind of chambered dock. So I awoke, and thought about the dream. The Angelic Spirits then . . . said that they had introduced this dream. And that I might know for certain that it was from them, I was let into a state as it were in sleep and at the same time awake, when they in like manner introduced various pleasant and delicious things . . . This was done . . . several times, and each time I was instructed by them *viva voce.* The Angelic Spirits who are at the threshold of the paradisiacal abode are they who insinuate such dreams . . . They belong to the province of the cerebellum, because the cerebellum . . . is awake while the cerebrum is asleep. From this source the men of the Most Ancient Church had their dreams, with a perception of what they signified; from whom came a large proportion of the representatives of the Ancients." (A. C., n. 1977.)

In yet another experiment, Swedenborg himself was permitted to introduce dreams, "and the other awoke," he says, "three or four times after dreams had been introduced by me; and I then related the things, which he acknowledged." (*Spiritual Diary*, n. 3181.)

In A. C., n. 5115, we are told that "the dreams which flow-in through Heaven from the Lord never appear otherwise than according to representatives." This being so, it would appear that realistic dreams must come from spirits in the intermediate World of Spirits who are in a degree of life but little removed from the natural. "For a spirit also has a natural life; for his spiritual life is terminated in a natural one; for man can not immediately after death think spiritually, except from such things as belong to his Natural." (A. C., n. 3293.) Such spirits, because they have a wider outlook over causes, may sometimes see a little farther into the future than we do, and through their association with spirits attendant upon other human beings who are still in our world, they may sometimes be able to report occurrences of which we should otherwise have no knowledge; but we should guard against supposing that these spirits are infallible, or that they are much wiser than we; nor could their testimony be accepted by a court of law without outside corroboration, although certain presentiments, such as that of the recent Wall Street explosion in New York, are well authenticated, and presumably come from intercommunication between spirits. The gathering of evidence in respect to presentiments and their more or less perfect fulfilment, or nonfulfilment, is one of the legitimate functions of our psychical-research societies.

To illustrate what is meant by a significative dream—

one which has its source in a mind of at least angelic comprehension ,and which is given to instruct the recipient concerning God's ways towards men, and one also which after the events foretold have been accomplished, helps us to recognize the Divine Providence preparing good fortune for the human race, or overruling evil for good—I will give five examples of dreams whose scope is world wide:

(1) *The Hague Tribunal.* Shortly before the Second Hague Conference, I dreamed that I was in a vast city which had been either deserted, or bereft of its inhabitants. I could wander at will through the streets and enter the houses whose furnished rooms bore evidence of recent occupation; but not a living soul was in sight. A feeling of loneliness and deep sorrow came over me, which was turned to fear when, in the distance were heard shouts, and looking out from a safe hiding place, I saw companies of *German* soldiers, armed to the teeth and riding on high bicycles, looking to the right and left to see if there was yet another inhabitant whom they might kill. This dream foretold the failure of the Conference to adopt measures for disarmament of the nations which resulted through the opposition of the German delegates who, even at that early date, had formulated plans for world conquest involving wholesale destruction of rival nations.

(2) *The Battle of the Marne.* On the Sunday before the battle, I saw in my dream a line of twenty-five drummers, beating their drums, and marching at the head of a column of French zouaves, also arranged twenty-five abreast. There was also a German woman with a plate in her mouth, asking for bread. At this time, to outward appearance, the cause of France looked desperate. It seemed as though nothing could save Paris. But God considereth the poor and needy. He will preserve his soul from deceit and violence. I saw

that the dream meant that the French would turn, they would advance, and Germany would suffer want. Before the week ended, there came the battle which will stand with Thermopylae, Marathon, Kossova, and other of the decisive battles of the world in which the forces of barbarism have been checked.

(3) *The World War and the Heavenly Powers.* On February 26th, 1916, I dreamed of wandering through the rooms of an immense house where were many men and women, apparently church people, but I sought only for my friend. At last I found him—a young man of commanding presence, but beautiful face. Could it indeed be the Friend of man? I thought of the Scripture: "In aspect like unto the Son of Man." He took me into a western room, where the afternoon sun shone through high windows, and talked with me; and as the sun began to approach the horizon, we went out and saw the sky covered with wonderful, bright clouds in intricate meshed patterns, like lace, some forming, as it were, garlands of beautiful geometrical figure, which changed form. I called the others to come and see, but only a few were interested. They saw not the "signs of the times," nor the near approach of Him who "cometh with clouds."

But now there appeared on the western horizon ominous *dark* clouds, which presently became a long train of iron cars on which German soldiers were loading great masses of clay, which one of their number fashioned into rude images of bears and lions, which were the supposed thunder-heads aforesaid. For Germany had long been heaping up the miry clay of a materialistic thought and life into images of fear and the iron organization of a heartless, destructive militarism.

It was one of the darkest periods of the war. The German drive on Verdun was about to assume terrific proportions; but lo! in my dream I was all at once in a large inner room, blazing with light; and an angel woman, most beautiful in face and with long, golden hair floating around her like an aureole, talked with me, telling me to fear nothing; and reaching forward, she gave me the sweetest of kisses on the lips; and I awoke, certain that the heavens were in control.

(4) *Verdun.* March 13th, 1916, I dreamed again of an approaching thunder-storm, much more terrible than the former one. Suspended in air was a fiery column, which drew near. This changed to a ball of fire with cup-like projections above and below. The thing stood still, threatening, and almost over the house. I was in trepidation, fearing some terrible explosion, and ran into the house to warn the inmates; but on coming out, the storm had vanished and a clear blue sky, full of bright stars, greeted me. In my record, I said: "Perhaps this means the stopping of the terrible German attack on Verdun. I hope so." The sequel proved it to be true.

(5) *America to the Rescue.* It was the week before the declaration of war by the United States. I dreamed that a great fire had broken out in the business section of the city in which I was; and down a broad avenue came a gigantic locomotive, as large as a house, drawing a train of huge cars from which roaring flames ascended higher than the roofs of the city; and it was said that they were going in to fight fire with fire—a scene of indescribable terror!

Comment is unnecessary. All will recognize in these images a faithful symbolic picture of coming events. Is it not evident that these dreams, foretelling the future, came from no ability of my own thus to foresee? Is it not assured that they must have come from that World of Causes where flow the sustaining currents of spiritual life which, like those great currents of the ocean over which man has no control, are bearing us on irresistibly to a futurity whose end is none other than the Kingdom of God on earth?

SWEDENBORG ON THE LIFE OF BEASTS

Swedenborg is very explicit in distinguishing the life of a beast from that of a man. Some treatises on psychology ignore the distinction altogether; though recent science is apt to coincide with our author in a general way but does not go to the bottom of a rational explanation of the difference and is often nonplussed by puzzling cases. One of the best recent statements will be found in the *Tertium Organum* of P. D. Ouspensky.

Many of the activities of beasts verge on the automatic. Some of our actions are also very nearly automatic, but such actions were, in general, originally carefully thought out and become automatic only after numerous repetitions and through the development of reflex actions from subordinate nerve-centers which thenceforth take charge of the operation and relieve the higher neurons of their responsibility.

Automatic actions, says Ouspensky, "are actions which have been conscious for a given subject, but because of frequent repetitions they have become habitual and are performed unconsciously. The acquired automatic actions of trained animals were previously conscious not in the animal, but in the trainer. Such actions often appear as conscious, but this is a complete illusion. The animal remembers the sequence of actions, and therefore its actions appear to be considered, *but not by it.* Automatic actions are often confounded with instinctive ones—in reality they resemble instinctive ones, but there is an enormous difference between them. Automatic actions are developed by the subject during its own life, and for a long time before they become automatic it must be conscious of them. Instinctive actions, on the other hand, are developed during the life-periods of the *species*, and the aptitude for them is transmitted in a definite manner by heredity. *It is possible* to call automatic actions instinctive actions worked out for itself by a given subject. *It is impossible*, however to call instinctive actions automatic actions worked out by a given species, because they never were conscious in different individuals of a given species, but were compounded out of a series of complex reflexes." (p. 80.)

Still more is it impossible for some of the most remarkable instincts to be consciously originated by animals, such as that of the hairy Amophila (described by Fabre in his *Hunting Wasps*) which stings its victim in the most scientific manner, planting its sting in *each* of the ganglia of as many segments of the caterpillar, without which precaution the caterpillar would not be paralyzed by the wasp's sting and the infant wasp would be destroyed by the thrashing about of its prey before the larva had a chance to begin to feed upon its host. Such instincts can not arise fortuitously, but must be given by immediate influx from the spiritual world. This does not deny that *some* instincts may have been evolved gradually through successive trial and error and slow modification. But even here, the impulse to carry on the trials is a physical one and evolves a less explicit spiritual influx, for even the tinest insect has a soul, though not an immortal one.

The instances which are often adduced to show that some of the higher animals can reason as we do, are in all cases predicated of animals which have come under the influence of man. They are *trained* animals, as Ouspensky pointedly observes.

The wild elephant uses its tusks as a lever with which to pry up and overturn trees that the herd may feed upon the foliage. The hog uses its snout as a lever with which to root up the ground. But no animal has conceived the idea of using an inanimate object, such as a stick, for a lever. The animal is incapable of *inventing* even this simplest of machines, for the reason that the animal has no *concepts*. "All actions of animals, sometimes highly complex, expedient, and apparently reasoned, we can explain without attributing to them concepts, judgments and the power of reasoning. Indeed we must recognize that animals have no *concepts*, and the proof of this is that they have no speech." (Ouspensky, p. 82.)

The story has been told of a cow which, being brought to a stuffed calf, proceeded to lick it with every manifestation of parental affection, but then, perceiving some hay sticking out through a rent in the hide, the cow nonchalantly pulled out and devoured the hay. The animal is governed wholly by its affections or by whatever affection happens to be uppermost at the moment, and its actions are not controlled by reason.

Ouspensky cites the case of a cat: "Her kittens—five or six in number—she dragged asunder into different rooms, and could not then collect them together. She seized one, put it beside another, ran for a third and brought it to the first two, but then she seized the first and carried it away to another room, putting it beside the fourth; after that she ran back and seized the second and dragged it to the room containing the fifth, and so on. For a whole hour the cat had no rest with her kittens, she suffered severely and could accomplish nothing. It is clear that she lacked the concept which would enable her to remember how many kittens she had altogether." (*Ibid.*, p. 93.)

The animal recognizes only the appearances given by the senses, without considering their meaning. "The horse is frightened by the bush because the bush unexpectedly turned and waved a branch. In the last case the bush need not even to have moved at all, for the horse was running and it seemed therefore as though the bush moved, and consequently that it was animated. In all probability all movement is thus animated for the animal. Why does the dog bark so desperately at the passing carriage? This is not entirely clear to us for we do not realize that to the eyes of the dog the carriage is turning, twisting, grimacing all over. It is alive in every part—the wheels, the top, the mud-guards, seats, passengers—all these are moving, turning. Because of the same law an animal can never understand *a picture*. The picture is immobile, while for the animal the world is always moving." (*Ibid.*, p. 100.) But just take the dog to a moving-picture show of a dog-fight!

For the animal, the world is like a moving-picture screen. It is two-dimensional. Indeed, for the snail and the caterpillar, the world is one-dimensional. All that it notices is the edible leaf just ahead. The caterpillar is completely oblivious to its surroundings. The papilio larva does not notice the approach of an enemy and does not display its protective scent-organs until it is touched. But on becoming a butterfly, the psychology of the creature is elevated to a higher degree. It rises above the earth and enters what, for it, must be a new world. It is no longer a creature of one idea, that of eating. Light, air, sunshine, flowers, the search for a mate—these make its new world. Its horizon has expanded.

We have seen that Ouspensky considers that instinctive actions never arise out of conscious actions in separate individuals of a given species. A somewhat similar conception has been put forth by Dr. E. Noel Reichardt in his book: *The Significance of Ancient Religions in Relation to Human Evolution and Brain Development,* which I have discussed in the New-Church Review for July, 1915. The speculations of this work concerning religion need not detain us, but the hypothesis that there are two sorts of heredity: (1) that which relates to family traits and preserves some of the temporary aberrations and peculiarities of individual lives; and (2) a deeper and more obscure but lasting racial urge, which passes through successive phases to a climax or wave-maximum, and then passes away. As applied to animal development, the hypothesis has a certain plausibility, though I am not aware that any confirmation has ever been found for the specialized existence of a *dual* germ-plasm, invented solely in order to account for the facts in a natural way.

Dr. Reichardt's point is, that certain phenomena are characteristic of *life-periods* of the *race,* and are not consciously dependent on individual action. In this respect they resemble the instinctive activities of individual animals, which Swedenborg explains thus: After telling us that there is an inmost degree of human life "into which the Lord's Divine first or proximately inflows," and which is lacking in beasts, he tells us, "that there is an influx from the Spiritual World also into the lives of beasts; but a general and not a special one as with man." (*Last Judgment*, n. 25.) A science which confines its attention to nature and ignores the existence of a *spiritual* world, can not arrive at just conclusions as to life which is uncreate and wholly spiritual as to its essence.

In the book, *Our Unseen Guest,* recently published by Harper and Brothers, the spirit of one who on earth had been a professional man and a friend of the late William

James (at least that is the claim) thus comments on free will:

"So closely is the amoeba related to mere chemical reaction that its agency seems quite chemical. Yet science recognizes it as more than simply action; it is life. Go up the scale of life now. More and more the living thing differentiates itself from chemical activity until at last instinct, a really understandable parallel to man's will, is reached. And then, especially in the domestic animals, we find instinct of a still higher order, yet it is not will; the stray dog pauses at a corner, then takes the route home, led by instinct and a form of memory that amounts almost to reason. The dog wills not. At last man is reached.

"What is the difference between the instinct which leads the dog to act and the will that prompts the action of a man? Is it not apparent that the dog's urge is conditional, not so conditional as chemical reaction, yet responsive for the most part only to stimuli, while man's will, far from being prodded into activity, is spontaneous, possessed of an actual freedom. . . . Man, in truth, can be defined only in terms of free will. He is the free-will degree of consciouness." (*loc. cit.*, p. 280-281.)

He goes on to say: "But not always does man's will choose wisely. The animal following its instinct seldom errs; a chemical reaction never errs. Not always does man's reason guide his will correctly."

To this extent at any rate, the better and more reliable communications from the spirit world* agree with Swedenborg, who says: "The reason beasts act according to the laws of order inscribed on their nature, and some of them, as it were morally and rationally . . . is that their understanding is blind obedience to the desires of their will; consequently, they can not pervert these things by means of perverse reasonings, as men can." (*Intercourse of the Soul and Body,* n. 15.)

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* The reader may ask: How do you know that these communications were received in the manner stated? How do you know that this is not a work of fiction? The answer is, that the publishers, who are themselves above suspicion, vouch for the honor of the anonymous recorders of these messages, and that the general tone of the writing is that of scientific people who reverence truth.

That which these spirit-communicants do not know, or at least do not acknowledge, and which constitutes a serious omission and gap in their argument, Swedenborg supplies in his statement that true freedom is not of man's making but is incessantly provided for man by the Lord alone.

To be led by the Lord is to enjoy the freedom. To follow the desires of the selfhood may appear like freedom, but is really slavery. Beasts follow their bodily appetites.

The distinction between human and animal life involves physiological differences. Man is the *thinking* animal. Man, when he deliberates, keeps his brain tense, and permits the influx of blood into that organ only along certain of the many ways in which it can enter. It is otherwise with beasts. They are swayed irresistibly by the currents of the blood and are completely controlled by their passions.

In his *Economy of the Animal or Soul's Kingdom* (Part II, n. 164-5) Swedenborg says of the cortical substance of the brain:

"That this cortical substance is disposed and distinguished in a peculiar manner in the brains of irrational animals, and exactly combined and fitted to the distinctive actions and life of each; and that it is supplied by sanguineous currents quite differently to what obtains in human brains. As respects the one point of the influx of blood, it is found that in the brains of brute animals, it is with difficulty that it is restrained from rushing in at the slightest instinct and intimation, and suffusing the cortical substance; so that their determinations, which are analogous to our voluntary determinations, result necessarily from the reigning temperament of their purer blood, from its state, and from its condition as altered in conformity with the times and seasons of the year, and with the contingent excitations of the external senses. On the other hand, truly human brains have the privilege and liberty of keeping the blood out at the doors of the cortical substance, and holding it at a distance so long as the mind is revolving its reasons; and even of blunting the acumen of the external organs of sensation so far as to prevent distinct perception of the objects presented to them. We shall have wonders to relate on these subjects in the Parts on the Brain. The brain, by this its faculty and force of animation, extracts, as we said, a most pure essence from the invited blood, and transmits it into the fibers, as its delicate appendages; and pours upon it a new essence conceived and excluded by a high process of generation in the finest wombs of its substance."

In Part I, n. 217, Swedenborg enters more into detail and explains that the internal branch of the carotid artery "enters the cranium through the foramen proper to it, in company with the intercostal nerve. It leaves behind its muscular tunic at the porch of ingress, beyond the limits of which tunic the heart of the body is unable to act; for the artery when deprived of this coat no longer has the character of a continuous heart, neither does it promote the circulation or propagate the wave. It presently winds into numerous gyres, as if it seemed in this manner to wish to shake off the yoke of the heart. This is first observable in the osseous foramen itself. It is again observable when it has entered the hollow of the cranium; again as it descends into the receptacula cavernosa; again while it is sojourning in this region; and again when having perforated the dura mater it climbs the brain. Not only does the artery divest itself of the muscular tunic, but it places itself under the control of the intercostal nerve (which in the body is in lieu of the cerebellum and medulla spinalis), and everywhere at the same time under the control of the dura mater; nor do these release it from their power and deliver it up to that of the brain, until it mounts the hemispheres of the brain, under whose control it thenceforward is."

After explaining how the individual cortical spherules are constructed out of the inmost nervous tunic of the arteries, and that "this substance is, by means of the same membrane, continued into the fibers, and thence again descends into the vessels of the body, where it completes its wonderful gyre," he continues:

"In brute animals, however, the case is different. Indeed, so great is the difference, that merely from a comparison of the determination of the arteries, it is clear, that animals are as much under the rule of their body as of their brains; which is the reason that they never cease to desire whatever their blood craves, and that according to the various changes and incitements experienced by their blood, they are led by blind instinct alone to the performance of the actions proper to them. In man, however, an entirely different communication takes place; a communication manifestly of such a nature as to be able to ward off the blood and detain it at a distance from the cortical substances, lest while the rational mind is occupied in revolving its reasons, the blood should too nearly approach, and interrupt its judgments, before the question is settled whether the will is to determine into act the appetencies excited by external causes, or those proceeding from the outward world through the external organs, and from the body through the medium of the blood."

In a note to the first volume of Swedenborg's work on *The Brain* (p. 318-319), Dr. R. L. Tafel says:

"Swedenborg in maintaining here that the internal carotid on entering the cranial cavity lays aside its muscular coating, bases himself on the testimony of Boerhaave. Burdach, among modern authors, expresses a similar view; for he says: 'After gaining an entrance into the cranium, the arteries give up their fibrous sheath, which passes over into the filamentous coating [dura mater] of the brain; and in correspondence with the sphere to which they henceforth belong, they acquire a peculiar character; for . . . together with their annular, muscular fibers they lose every vestige of a proper or independent irritability by becoming thin-coated' . . . Other authors, again, while granting that the internal carotid on entering the cranium gives up its fibrous sheath, do not admit the fact of their likewise laying aside their muscular coating; and yet they agree that the coatings of the arteries in the brain become very much thinner. So Quain says: 'Some arteries want sheaths, as those, for example, which are situated within the cavity of the cranium.' And afterwards he continues: 'Some arteries have much thinner coats than the rest, in proportion to their caliber. This is strikingly the case with those contained within the cavity of the cranium and in the vertebral canal; the difference depends on the external and middle [muscular] coats, which in the vessels referred to are thinner than elsewhere.' . . . It stands to reason, however, that when an artery 'loses its annular, muscular fibers,' or when its muscular coating 'in proportion to its caliber' becomes much thinner, 'every vestige of its independent irratibility,' as Burdach says, 'is lost.'"

Swedenborg also infers that the animal is more immediately governed than man by certain forms of motion in the natural atmospheres:

"The human race is wanting in an interior sense which brute creatures enjoy, as instanced in their sense of place, or that which makes them to recognize where a certain place is and thus to learn by what way to return home and regain their accustomed meadows and streams. They know this notwithstanding they find their way by an entirely different path and one which had never been trodden or scented. Thus they are like living magnets. Such a sense arises from the form of the cortical glands themselves, which form is vortical, and can not be excited by the fluxion of substances without a determination of the poles and of the larger and smaller circles, such as is seen in the great system. But man is wanting in such a sense, because of the intellect or our possessing a certain higher perception which induces an activity in those glands, so that the sensations of sight may be rightly perceived. This intellect is not pure, but mixed, hence it does not attend to the slightest motions of the objects of sight, and it governs the state of its gland from its own will, and not from nature or a natural intelligence. Therefore it can not be otherwise than that such a sense is wanting in man while it is enjoyed by those brute creatures which are not possessed of such an intellect." (*The Soul, or Rational Psychology*, n. 90.)

Treating of the same subject in the *Economy* (Part II, n. 339), he says:

"In numerous cases animals have shown the most exact and complete capacity to turn to the different quarters of the world, and to return to their homes over miles of ground, through paths that they had never before smelt or attempted; and in like manner to betake themselves to their pastures, stables, hives, streams, houses. We allude to dogs, horses, bees, ants, crabs, etc., all of which may be compared to living magnets, since the magnet has in it a similar directive force to these animals. That this force owes its origin to the second ether, was shown in my *Principia*. . . . With man this force can not be connate, because the direction of the first aura is universal, as the direction [ruling, or directive force] of the created universe."

Here animals are likened to magnets. By the "second ether" is meant the magnetic element, elsewhere called the "aura," and by the "first aura" I think we must understand the atmosphere of the spiritual world by which nature is sustained, but which is not itself spatially directed. Man, equally with the animals, possesses an organic form, or limbus, made out of the magnetic aura, or possibly out of an intermediate atmosphere, a question which will be considered in Section C of this chapter. The point is that man does not attend to, or perceive the magnetic indications, because otherwise occupied; though there do appear to be exceptional individuals—Reichenbach's "sensitives"—who possess a modicum of magnetic sense.

Swedenborg, who is on record as asserting that man has a fluent atmospheric (aural?) form, adjoined to the gross material body, evidently here conjectures that animals must also have an analogous atmospheric organism, but it can not be permanent and must lack something which man has, presumably the spiritual body composed of the substances of the spiritual world. Psychical research has obtained evidence that animals sometimes see phantoms (human limbi?), just as some human beings can have their spiritual eyes opened to discern objects in the spiritual world. But these inner perceptions of beast and men are a discrete degree apart. It is admitted that beasts have brains with numerous parts entirely similar in general external form and disposition to those in the human brain; but "the animal soul is as different from the human, as air is different from ether, or hearing from sight. . . . The former scarcely extends its sphere of perception farther than a few yards, before it begins to grow indistinct and dull; the latter extends its sphere, almost without degrees and moments, beyond the [terrestrial magnetic?] vortex to the sun and stars. And we are convinced by a careful examination and comparison of the operations of both that even such is the difference in point of perfection between the souls of brutes and the human soul." (*Economy*, etc., Part II, n. 344.)

The supposition that animals are "living magnets" is a speculation which may be difficult of verification, but it is the only one in sight which even professes to explain a most extraordinary fact.

In the *Principia* Swedenborg says:

"When a motion passes from a grosser medium into one that is more subtle, it becomes successively more sensible; and if more sensible, then more distinct. We are distinguished therefore from brutes by this, that their perceptions do not penetrate to so subtle a medium as they do in man, but that they stop as it were midway, where perception is not so acute and less distinct." (New English Edition, Part I, Chap. I, p. 11.)

He states further, concerning education, "that man is perfected by exercise, and that the organs which are intermediary between the senses and the mind are formed by constant cultivation, and that without cultivation and exercise these organs would be closed. . . . The very slowness of his progress from infancy to manhood, contributes in a very fundamental and essential manner to the formation and opening of such organs or motions in the most subtle membranes; not to mention the construction of the brain itself. For we do not arrive at adolescence till after fifteen or twenty years, or more; whilst the larger, stronger, and more muscular animals arrive at maturity in between three and four years." (*Ibid.*, p. 12.) "The longer, therefore, an animal is in arriving at maturity and the full tension of its parts, the more open will the passage to its most subtle organs become, the thinner will be the coverings of its membranes and parts, the more compliant to the motions impressed on them, and the more numerous the ramifications into which it will extend; consequently, the more perfect will the animal become, provided the means which can perfect him are employed; which consist, as was before said, in perpetually calling his faculties into use, cultivation, and motion by means of education." (*Ibid.*, p. 13.)

But while the higher animals may be divided, as Bonaparte and Gill have done, into two great groups—*Educabilia* and *Ineducabilia*—the fundamental distinction between man and the animals still remains unbridged.

Those who have imagined that animals live after death and have immortal souls, are much deceived. It is true that spirit-forms of both plant and animal likeness appear in the spiritual world in all of its domains, but they are not continuations of the corresponding earthly forms, neither have they permanency, but they come and go according to the varying states of angels and spirits, from which they take their rise and to which they correspond. Animals are described in the Apocalypse, but they are obviously symbolic. Similarly, Swedenborg assures us that they exist in great variety and perfection in the heavenly world, but equally as symbols.

"Various beasts appear in the Spiritual World, but they are not such beasts as are in our world, that is, beasts which have been born; but they are correspondences of the affections and derivative thoughts of Spirits and Angels; wherefore as soon as those affections and derivative thoughts are varied and cease, they vanish out of sight." (*Apocalypse Explained,* n. 817[18].)

In the World of Spirits, elephants are seen, but nowhere else, and this because elephants correspond to a strong love of justice, which is one of their chief characteristics, and the World of Spirits is the Judgment World where equal justice is meeted out to all, and where separation of the good from the evil is effected. Solomon had a throne made of ivory, because he knew of this significance.

Teeth, because they are used in a first external examination of foods as to hardness or consistency, and are employed in comminuting food preparatory to its more interior appreciation by the organ of taste, represent those faculties which first test facts by external sensual examination, and thus form a part of the intellectual apparatus for digesting truths, first by a more external judgment of their quality and then successively by fuller and more interior perception of their real nature. The elephant's tusk is a tooth extraordinarily developed. It has great power, is used as a lever with which trees may be uprooted and overturned, preparatory to the animal's feeding on their foliage. Elephants also have a keen sense of smell and the tip of the nose is enormously produced and used as a tactile and prehensile organ in the further examination of objects, the whole corresponding to an acute perception in forming correct judgments. The elephant is thus provided with a paraphernalia which enables it to play a part representative of the initial judgment, leading up to its final phases; and the office of the entire digestive tract corresponds to the separation of the good from the bad which is what goes on after death in the intermediate "World of Spirits" between Heaven and Hell. But because Swedenborg saw elephants there (A. E., n. 1200), it must not be supposed that earthly elephants live after death.

We have not room for the many interesting descriptions of Swedenborg's experience in the spiritual world which completely establish his position that animals have not immortal souls; but the argument is sufficiently founded in the words of Jesus: "And this is life eternal, that they should know Thee, the only true God, and Jesus Christ whom Thou didst send." (John, XVII, 3.) Animals can not know God and therefore do not have eternal life.

"The interiors of man, which belong to both his minds, can be raised by the Lord, and be conjoined with Him; hence it is that every man lives to eternity. It is not so with a beast; it does not enjoy any spiritual mind, but only a natural one; therefore its interiors which are solely of knowledge and affection, can not be raised by the Lord, and be conjoined with Him, wherefore it does not live after death." (*Apocalypse Explained*, n. 1202[5].)

If more than this is desired, we must seek the reason for these assured facts in fuller knowledge of spiritual principles. Any one who has no more spiritual life than an animal, is spiritually dead. We may be instructed by the internal sense of Genesis iii, 17:

"That to eat of the ground in great sorrow signifies a miserable state of life, is very evident from what precedes and follows—also from this, that eating in the internal sense is living—and from the fact that such a life follows when evil spirits begin to contend, and the angels with a man to labor. Still more miserable is it afterwards when evil spirits are beginning to rule; evil spirits then govern his External man, and Angels the Internal, of which there is little left—so little that the Angels can scarcely take anything thence with which to defend him. Hence misery and anxiety. That men who are [spiritually] dead rarely feel such misery and anxiety is because they are no longer men, although they esteem themselves men above others. For they know no more than brutes of what is spiritual and celestial, and of eternal life. Like them they look downward to earthly or outward to worldly things, favor only their proprium, and indulge their natural inclinations and senses—all the rational consenting. And because they are dead they would not sustain any conflict or temptation—which if it came upon them would be so grievous that they could not live; and they would thus curse themselves the more, and plunge themselves more deeply into infernal damnation. For this reason it is spared them until they pass over into the other life, when they can no longer die from any temptation and misery. Then they undergo sufferings the most severe. These things likewise are signified by 'cursed is the ground,' and 'in great sorrow shalt thou eat of it.'" (*Heavenly Arcana*, n. 270).

This lesson has also been taught by my uncle in his poem:

THE DEAD[*]

I see them,—crowd on crowd they walk the earth
Dry leafless trees to autumn wind laid bare;
And in their nakedness find cause for mirth,
And all unclad would winter's rudeness dare;
No sap doth through their clattering branches flow,
Whence springing leaves and blossoms bright appear;
Their hearts the living God have ceased to know
Who gives the spring time to th' expectant year;
They mimic life, as if from him to steal

[*] Essays and Poems. By Jones Very. Boston: Little and Brown, 1839. (See page 146.)

His glow of health to paint the livid cheek;
They borrow words for thoughts they cannot feel,
That with a seeming heart their tongue may speak;
And in their show of life more dead they live
Than those that to the earth with many tears they give.

To be spiritually alive, man has to have freedom. True reedom, as we have said, is of the Lord alone and can not e given to animals. The following passages ought to make t clear why this must be:

"In all self-compulsion to good there is a certain freedom, vhich is not discerned as such when one is in the work of ompelling, but still it is within. . . . This is the case most f all in temptations, for in these when a man compels imself to resist the evil and falsity which are infused and uggested by evil spirits, there is more of freedom than is ossible in any state out of temptations, although the man an not then comprehend this; for there is an interior freelom, from which he wishes to subjugate evil, and this so reat as to equal the force and strength of the evil which ssaults; otherwise he could not contend with it. This freelom is from the Lord, Who insinuates it into the man's onscience and by means of it causes him to overcome the vil as from what is his own. Through this freedom man cquires a nature of his own into which the Lord can bring ood. Without a nature of his own acquired, that is, given, hrough freedom, no one can ever be reformed; because he an not receive the new will, which is conscience." *Heavenly Arcana,* n. 1937$^{4-5}$.)

"This freedom is what the Lord thus speaks of in John: The truth shall make you free. . . . If the Son make you ree, ye shall be free indeed.' (viii, 32, 36.) What this reedom is, they who have not conscience do not know at ll; for they place freedom in doing as they please and in the license of thinking and speaking falsity, of willing an doing evil, and of not compelling and humbling, still less o afflicting such desires; when yet it is just the other way, a the Lord also teaches in the same gospel: 'Every one tha committeth sin is the bond-servant of sin.' (viii, 34.) Thi slavish freedom they receive from the infernal spirits wh are with them and who infuse it, and when they are in th life of those spirits they are also in their loves and lusts; a impure and excrementitious enjoyment breathes upon them and when they are being carried away by the torrent, as i were, they think themselves in freedom, but it is inferna freedom." (*Ibid.*, n. 1947^{3}).

"The reason so many men do not know how to distin guish between their own life and the life of beasts is that they are similar in external things, and care onl for earthly, bodily, and worldly things." (*Ibid.*, n. 3646^{3}.

"Of those in the Christian World who are called inte ligent, there are very many who reject from their faith th immortality of their life, believing that the soul of a ma is dissipated after death equally as the soul of a beast; no perceiving the difference of life between a man and a beast that man can think above himself, about God, Heaven, lov faith, spiritual and moral good, and the like; and thus tha he can be elevated to the Divine itself and be conjoined wit Him by means of all these things; but that beasts can no be elevated above their own Natural to think such things. (*Last Judgment*, n. 25^{3}.)

Let us examine the difference between men and anima further from the anatomical side. Yet another physiologic distinction between animals and men is brought forwar in the *Economy*, Part II, n. 340:

"In animals a very broad passage leads into this [th pituitary] gland through the beak of the infundibulum, c so much greater caliber than the corresponding passage in human brains, as plainly to present the appearance of a hollow tube, and easily to allow the injection of a colored liquid. In the human brain, on the contrary, the passage is so narrow, that neither is it visible to the eye, nor can any elementary fluid be made to permeate it; except that the mere beak of the infundibulum performs the office of a sieve to an essence of the subtlest kind. But perhaps this may not be considered sufficient proof of our view, because the genuine use both of this gland, and of the infundibulum, and ventricles, is not yet recognized; and as long as the use is a moot point, any induction from use furnishes no sort of proof. The arguments then from the brains, and from anatomy generally, must be brought together in other Parts of our Work. Meanwhile, from those brains that I have examined, I have convinced myself, that there is as great a difference between the animal fluid and the human spirituous fluid, as there is between a lower and a higher degree."

And in n. 343 we read:

"The brains of different species of brutes differ respectively according to the nature of their souls; and not only in bulk, but in figure and disposition of parts, and especially in the direction and dispensation of the fluids, as they pass from the outer sphere to their cortical substances; and this, entirely in accordance with the nature of their purest fluid, which is the cause of all the consequent fluids, since it is the formative force and substance that draws the thread from the first living point and continues it to the last point of life."

The researches of G. H. F. Nuttall, G. L. Graham-Smith and T. S. P. Strangeways ("Blood Immunity and Blood Relationship." Cambridge: 1904) have confirmed this much of the foregoing proposition;—These investigators find variations in the composition of the blood of different animals, and what is most interesting, the blood-test confirms the relationship between various groups of animals, many of which had already been inferred from evolutionary theory, based on the succession of the groups in the paleontological sequence, as well as upon other considerations.

In his great work on *The Brain* Swedenborg has examined the problem of the use of the pituitary gland much more extensively through a process of reasoning founded on the intricate anatomy of these parts. Nothing more plausible has ever been suggested as to the use of these organs, and, indeed, nowhere else is anything extant which so well deserves to be called an explanation of these obscure functions. The anatomists whom I have consulted, one and all say: We do not know the meaning of these things. This being so, let us listen to Swedenborg's attempt to solve this difficult problem.

He states that the pituitary gland secretes three different orders of a pure "spirituous" lymph, derived from the cerebro-spinal fluid admitted through the infundibulum. An anterior chamber receives pure arterial blood from the carotids and this is "wedded" to the purest spirituous fluid which has been filtered through passages so fine that, though suspected, they have never been satisfactorily demonstrated. This fluid is so easily dissipated that it can only be preserved by union with certain elements of the blood, from which union results a new sort of vitalized particle. The existence of such particles was confirmed by an observation by Professor Franz Leydig in 1852 (See Tafel's notes to the second volume, pages 473-4.) By devious ways, according to Swedenborg, the several orders of this pituitary lymph are injected into the venous blood to restore its vitality. That of the second order is said to be stored in the cells of the sphenoid bone and the petrous portion of the temporal bone from which, since these cells are not provided with any contractile membrane, Swedenborg avers that the blood and lymph are shaken, or jarred, by receiving a tremulous motion from the vibrations of the neighboring internal ear; and he cites the beneficial action of hilarity on the digestion, as due to its aid in releasing the contents of these cells and thus invigorating the blood. The subject is discussed at length in Tafel's notes.

The spirituous fluid of the first order is ascribed by Swedenborg to its direct inflow into the pituitary gland through fibers coming from the brain, where the fluid is formed in cortical glands and forced into the tubular fibers by contraction of these spherules. Tafel notes a certain amount of confirmation by Virchow who says:

"In the interior of the infundibulum there is continued very decidedly the ependyma of the third ventricle which forms a soft, very frail mass rich in nuclei. This mass, in its outer surface, almost always gives evidence of a very scanty presence of nervous elements. Among these there are occasionally *dark-bordered nerve-tubes* which accompany the infundibulum from above downwards. Nevertheless, I could not observe nervous fibers in all casses. . . . As to the gland itself I noticed in the posterior lobe dark-bordered nervous fibers; but in the anterior lobe never." (*Ibid.*, p. 450.)

It seems probable that there are several kinds of nerve-fibers, some of which are hollow and convey a liquid. But when Swedenborg speaks of the animal spirit (by which he means a refined, limpid, transparent liquid) as "flashing through" the nerve-fibers in the various acts of sensation and activation, we must demur that no liquid could pass so rapidly through such fine tubes, for the friction would be too great. We should now conclude that both the nerve-axis and the brain-cell are constituted of a highly organized gelatinous substance, and that the nerve-impulse is a wave of chemical metabolism, analogous to the formation and immediate destruction of a ring of sensitive film which travels along the surface of an iron wire immersed in dilute nitric acid, with a speed which is entirely similar to that of the propagation of the nerve-impulse, as suggested by Lillie.

The things narrated in this section show the unreliability of those communications received through mediums in which ignorant spirits assure us that it is a fact that animals live after death, because they have seen them.

SPIRITISM

As to the voluminous literature of spirit-communications through mediums, the larger part of it is rightly rejected by psychical research as having no evidential value whatever. Much of it consists of sentimental rubbish. We may be perfectly sure that the angels and the revered personages of history whose names are so often attached to these alleged communications from the spirit world, have been shamefully maligned. The flowery language, the attempts at "fine writing" (the bane of immature tyros in the art of composition), the inanity of the sentiments expressed, the total absence of any useful purpose in the messages, and a very large admixture of demonstrably false conceptions, brand these spiritistic writings (assuming that they do come from spirits) as mainly the work of low and ignorant minds; while the frequent insinuation of scandals against the Holy Word and our Lord Jesus Christ confirms the suggestion that the majority of these attempts to ensnare the weak and gullible emanate, as Swedenborg tells us they do, from *the Pit*.

The book from which the quotation on free will is taken
as, however, a wholly different flavor from that of the
rdinary spiritistic literature with its inane follies. *Our*
nseen Guest does not purport to be divinely inspired,
ıt is given as the philosophy of one who was killed in the
reat War—a man of high soul and great accomplishment,
ere permitted to come back and give us his enlarged
ought from what he has learned through his experience
f the Great Change, his "graduation" he calls it.

Swedenborg tells us that evil spirits desire to dominate,
ıat they hate the Lord, and try to infuse their insanities
ıto those whom they approach. This is why "to speak
ith Spirits is rarely granted at this day, because it is dan-
erous; for the Spirits then know that they are present with
ıan, which they otherwise do not; and evil Spirits are of
ıch a nature that they regard man with deadly hatred, and
esire nothing more than to destroy him, both soul and
ody." (H. H., n. 249.) This was written in 1758. Even
ıen, such speech with spirits was sometimes, though rarely,
ermitted. With the progressive increase of the power of
ıe New Heavens, may we not expect that such permissions
ill be more frequent? And to what spirit could this priv-
ege of speaking with men be given more safely than to one
ho had given his life fighting beside Michael and his
ngels against the Dragon? I have examined this remark-
le book carefully. The experiments recorded, while they
ake use of the internal memory and faculties of a woman
f earth (as in all mediumship a human brain is needed to
ceive the message), appear to have been designed with
ecial care so as not to infringe her freedom any more
ıan is absolutely necessary. In the method finally adopted,
is arranged that the communicating spirit shall use this
oman's organs of speech, but only with the consent of her

husband who keeps the record. With the wife's consen
by a touch upon her wrist, the husband notifies the spiri
that they may enter, and by a similar signal the permissio
is withdrawn. The communicating spirits, thus set apart
consenting to be bound by a strict law which shall not
infringed, form a band of investigators who are as muc
interested in the results of the experiment as any group
scientific earthly investigators. With all their enthusias
they are delicately considerate of the welfare of their i
strument. They note any sign of weariness in "Joan" an
advise postponement. They seem to have adopted th
motto: "Not to be ministered unto, but to minister.
"Stephen" speaks of the Christ as if from personal know
edge and with utmost reverence: "Remember this: Chri
is. He is in the world of men today just as truly, just
personally, as when He lived with men. He is more truly
your world today than then; for now He is supreme.
(p. 317.) Surely, this is no devil's work, even grantin
that it comes from a spirit in the intermediate World
Spirits, and who is therefore immature, and not yet read
to be elevated to the perfect day of angelic wisdom, thoug
with much in his philosophy which is worth thinking abou
What if there be some errors? Let us discuss them in th
light of the New Revelation. If those who are looking
the New Church for guidance in spiritual things have th
truth about immortality, they need not fear to bring Sw
denborg's disclosures into contrast with these doctrines
enthusiastically espoused by a novitiate spirit. Swede
borg's unique preparation for his mission places him befo
us as seer and revelator with twenty-seven years' experien
of the spirit world. "Stephen" is, at best, a somewhat spec
lative philosopher with but a few months' experience
the things of which he speaks. I proceed to discuss th

new departure in recent spiritistic literature whose only rival so far as I know as to the clarity with which it treats of a wide range of phenomena of the "subconscious" and spiritistic "philosophy," is to be found in passages relating to the same themes in Sir William Barrett's book: *On the Threshold of the Unseen.*

"OUR UNSEEN GUEST" *

Three persons of exceptional intelligence and wide reading, but with a strong materialistic cast of mind (one of them a disembodied spirit who is the prime mover) are principally concerned in this narrative. The accidental finding of an ouija-board with its attached instructions starts a man and his wife (wholly skeptical of the possibility of communicating with spirits and, though church-going by habit, disbelievers in immortality) on a course of experimenting in the reception of spirit messages—first by the board, afterwards by more refined and efficacious methods. The law of spiritual attraction has brought kindred souls together. The control—a spirit who had once been as skeptical as themselves—was an American of distinction, had been decorated by France for gallantry in the Allied cause, and had been killed by a shell. As he would be well known, his real name is withheld at his own request, as are also the names of the associates into whose life he came. Considering the importance of this work, we can not help feeling that in an age in which there is to be "nothing covered which shall not be revealed," this concealment is a mistake.

"Stephen," as he wishes to be called, first announced himself on the night of December 7, 1916. He had been previously unknown to the recipients of his message; but a little over a month later they found his record corroborated in every detail in the book to which he had directed them. Even this, however, failed to wholly convince the skeptics, until they had tried and rejected every other explanation of which they could conceive (including the usual "sub-conscious" hypothesis, which was conclusively shown to be untenable), and after various "tests," whose cumulative force became overwhelming, were ready to admit that the dead rise again, to take "Stephen" into their confidence, and to listen to his philosophy.

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* Our Unseen Guest. Anonymous. New York and London: Harper and Brothers. February 1920. 320 pages.

Having himself passed through the grim experience of a violent death, a part of his work in the spirit-world is at this time "the meeting of frightened boys coming from the battle-fields. . . . We on this side," he says, "do not bodily carry the new-comers from Europe's modern trenches. Yet some ancient Norse minstrel had a glimpse of the truth when he sang the story of the Valkyries." This experience is of course abnormal. Possibly, owing to the sudden snatching apart of body and spirit, such individuals may for a while retain an exceptional hold on matter, may continue to see through the eyes of comrades the paraphernalia of war, may by their continued and felt presence and strong excitement urge their associates to deeds of valor, and may hover over the battle-field as a floating cloud of "astral bodies," visible as such to those of the soldiers who are seers, inducing visions of the armies of heaven fighting for them. Such, at least, would account for "Stephen's" persuasion that the spirits of the fallen see *material* things, and for some of the stories that have been passed on to us by survivors of the conflict (the story of "The Angels of Mons," etc.)

"The soldier-boy," according to this one who claims to speak from experience, "having reached home, is greatly grieved that his presence goes unnoted by those he loves. You see he does not yet realize he has graduated. If we can get early control of those who come to us from the battle-field, and can take them to some quiet spot away from the upheaval, we are able to teach them quickly the truth and joy of their immortality." (p. 156-7.)

"Let us say the head of a soldier-boy is shot off—an unpleasant thought, though an occurrence many times daily on the battle-fields of Europe. In a trice the boy is free from his body, and so sudden has been his passing that none is there to meet him. He will see what he recognizes as himself, lying mangled; yet he will feel himself alive. Perhaps he will recognize the dead body of a comrade, also just graduated. They see each other double, as it were. They begin communicating, both utterly bewildered. That is the horror—neither knows what has happened or where he is." (p. 157.)

These assertions as to loved ones seen by them, but who do not reciprocate, are found frequently in the messages given by communicants. It may be true in the given abnormal case, but in the main we believe the immature spirit's impression is founded on a delusion, nor need we accept the ideas and hypotheses of a tyro, a novitiate, as in all respects a fully proven "philosophy." Bearing in mind that Swedenborg tells us that those who are in the spiritual world do not see the spirits of men still clothed with the material body, except occasionally when the latter are in states of abstraction and temporarily are partially separated from the body, still less can they see the things of nature, we might suspect that "Stephen" is romancing. To be sure, spirits who are materialistically inclined, and who have learned the trick of taking possession of the body of a medium, can see through the latter's eyes the things of earth. If the untrained and greatly shaken spirit of one killed in battle can perform such feats, it must be by some very extraordinary clinging to the material, which endures only for a little while.

Swedenborg tells us of a spirit suddenly released from the body through a violent death who was seen to run as though seeking to escape from something inspiring terror; and in *Spiritual Diary*, n. 5099, he tells us that Brahe "was executed at the tenth hour of the forenoon; and I saw him, and we spoke together, at the tenth hour in the afternoon, thus twelve hours afterwards; and, after that, for several days almost continually." Evidently, a violent death interferes with the usual orderly and graduated mode of resuscitation under angelic ministration, described in *Heaven and Hell.* (n. 445 to 452.)

"Stephen" tells us that "when death comes naturally, there are always those here to meet the voyagers [herein agreeing with what Swedenborg says.] But there was no one to meet me, no one to explain that I had graduated into a new plane of consciousness.

"At last one came, a woman, a very sweet woman whose service here has done much to alleviate the shock of battlefield graduation, and took me by the—shall I say, hand?—and led me to a—may I say, quiet woodland spot?—where after a time I learned the hope, the reality of the triumphant blessing I had achieved.

"And so I have chosen my work here, and with that work I go on—the comforting of those who come to us suddenly out of the shock of battle. I meet them, poor frightened soldier-boys, and teach them the truth—the simplicity of their own immortality." (p. 9.)

This at least does not disagree with Swedenborg's statements in regard to those who have suffered a violent death, and it suggests the essential goodness of heart of this spirit, even if some of his philosophy may be a little astray. In regard to the latter, we may note that "Stephen" professes to believe in reincarnation, but presently distinguishes between this and "what the world has meant by reincarnation," dismissing the latter as only "a glimpse" and a Buddhistic "emotional hypothesis." If angels, or angelic societies, may serve as instruments of creative influx, *this* sort of "reincarnation" is one that we can accept, and apparently this is what is meant. On page 245, there is a partial recognition of something suggestive of spiritual influx, in the idea that, while the individual is not reincarnated as a whole, certain of the qualities belonging to numerous disincarnated spirits are conjoined and infused directly into each new individual birth, and that in this resides the possibility of the gradual improvement of the race and a human evolution which is not a mere succession of parental replicas. Swedenborg teaches that the material body is put off at death "never more to be resumed," and that each individual remains his own peculiar self forever, though continually passing through new experiences.

"Stephen" believes in hell, but it is the "hell" of the "soul imprisoned in the torment of its own regrets, its own remorse, its own repentance." (p. 289, 290.) Swedenborg, however, from a wider experience, demonstrates that there is no such hell. The soul that regrets its failure to live is on the road to success.

"Stephen" also professes to believe in God. Nevertheless, though he speaks reverently of the words of Christ, he does not distinguish God from what Swedenborg calls "the Grand Man," made up of the totality of the heavenly societies.

In the philosophy, if instead of "quality of consciousness," we read "good of life," and for "quantity" substitute "understanding, or experience of the truth in its continuous and discrete degrees, obtained through living," the philosophy could be made over so as to harmonize pretty well with Swedenborg's. To put it another way, "quality of consciousness" is the essential vital principle of the individual soul—a gift from God. It is the gift of the talents in the Lord's parable, "unto each according to his several ability." The use that is made of the talents is their "quantity," much or little according as the opportunities of this earth-life are used or abused. But before this reconciliation of conceptions could be accomplished, there would have to be introduced at least one vital, or revolutionary change.

"Stephen" teaches that "force, matter, chemical reaction, life, these constitute the ascent, qualitative as well as quantitative, of consciousness." (p. 220.) "The atom, in one form or another, is the basis of all matter, all energy. The only thing I have to tell you is that it is the basis of all consciousness, of all degrees of consciousness from the intangible existence we have just postulated right up to supremacy itself. But keep clearly in mind that the atom is consciousness; nothing new was introduced; degree simply was developed. There was no creation; there is but the development of higher and higher degrees of consciousness." (p. 221.)

In all this, where do we find God? What is there other than developing atoms? On page 221 the atom is called "the basis of all consciousness." On page 260 consciousness is said to be "fundamental" and matter one of its "attributes." Here is hopeless confusion as to fundamentals. We are told that "the world has known the quality of him the ages have called the Christ. That quality was so near the height that, quantitatively fulfilled—and it was so fulilled—it attained, at earth graduation, the height." (p. 270-71.) This at first seems like a glorification of the Lord, ut it turns out to be only a glorification of the omniscient tom! For what though it be "essential that the atomic otentiality should have inhered in consciousness from the eginning," must the existence of the supreme be dependent n the existence of an atom? "Consciouness," we read, "is its own creator, its own savior. But, if you will, translate the supreme degree of consciousness as God. And if you are shocked by the thought that supremacy was not always existent, except as a potentiality, consider that consciousness, being the all, is time itself." (p. 273.)

Swedenborg teaches that there is a natural world, a spiritual world, and a divine world, but the last precedes. To reverse this order is to hold that God has been formed by nature, or that there was a time when God was not. This is materialistic evolutionary hypothesis gone mad. Of God the Creator, of evolution by spiritual influx into lower recipient forms, of heavenly order, and of Divine Providence, the author of this scheme has no knowledge. The definition that "God is Consciousness" does not rise above the sense plane. God is Life itself, and consciousness is the perception of the recipient of that life.

Because he knows nothing of heaven, or possibly because, being in a materialistic state of mind, the Lord's answer to the Sadducees is the only one that has been or could be given to him, "Stephen," in answer to the question: "What of sex?" replies: "In heaven there is neither marriage nor giving in marriage. . . . There is a parallel to what you know as sex, and I am told the parallel reaches even into supremacy." (p. 235.) Of the wonderfully satisfying revelation for the New Church that Conjugial Love is the highest and holiest of all loves and that it reigns supreme in heaven, there is at most only a feeble glimmer.

Must we conclude that, like most spiritistic teaching, this is a subtly concealed form of materialistic nature-worship and its fantasies? I prefer not to take this view on account of the kindliness and the helpful spirit of this book. While the fantasy is undeniably present, the false doctrine is sufficiently answered by the Scripture: "No one hath ascended into Heaven, except He who came down from Heaven, even the Son of Man who is in Heaven." (John, iii, 13.) Evolution is from the inflowing life of the Divine Love which has formed both atom and man. In spite of his illusions, "Stephen" seems to me both salvable and lovable, because he wants to help others. (Compare A. C., n. 318.) He sums up his philosophy in reducing it to the practical, as follows:

"Christ preached this, 'Inasmuch as ye have done it unto the least of these my brethren, ye have done it unto me.'

"Man through the centuries has gloried in this saying of Christ. Yet the literal truth contained in the words has by most men been only glimpsed. There is but one reality. There is but one 'me,' of which 'the least of these' and the greatest are but parts. Do it to another and you have done it to the whole; serve the whole of which you are a part and you serve yourself." (p. 293.)

And the woman through whom "Stephen" has communicated (who is also the wife of the anonymous recorder by whom these orphic sayings are set down and commented on), she who has demanded "something practical," as distinguished from philosophic speculations, on hearing this says: "If we are all just partners in the common business of a one reality, itself imperfect, but developing toward perfection, then the only really practical thing in the world is service." And the oracle assents: *"Service, the badge* *of quality quantitatively fulfilled, is the simple process of iving fully in one's appointed place,"* (p. 299) which practically coincides with Swedenborg's definition of charity.

The narrator reënforces the philosophy by an illustration of what he calls "pluralistic monism:" "You know that he many individuals who compose that orchestra will not cease, during the performance of the symphony, to exist as ndividuals, that instead they will become more individualstic than ever. Yet, not in spite of that accentuation of ndividuality, but because of it, the orchestra becomes for the period of the number a whole.

"And as the music throbs on, a hush falls over that audience of fussy men and women, deepens, broadens, uniting those who play and those who listen into a oneness wherein the parts are so delicately, so rapturously related that surely Stephen is right when he says, 'Lay the emphasis on oneness, always on oneness.'" (p. 206, 207.)

Here surely is a thought in which we can all acquiesce. Though there are successive discrete degrees of reception of life, yet this does not prevent the universe from being a *one* formed out of the many.

All are but parts of one stupendous whole,
Whose body nature is, and God the soul.

Viewed in this way, philosophic discussions of "monism" and "dualism" cease to contain the elements of conflict. It is possible to hold both conceptions without rejecting either; nay more, to accept the phrase which the recorder has adapted from William James, and speak of "pluralistic monism." We are approaching the ideal of "the many in one," held no longer as a merely fanciful, or taking phrase, but brought down to earth in concrete form. The very conception of this book demonstrates the possibility of a complete coöperation between intelligences on the mundane sphere and disembodied spirits, at least when they are in the same degree of life; and by a more purely spiritual and hidden, though no less real, interior activity, angels can be consociated with men on earth in good works; and always our thoughts may be clarified if we open our hearts to receive "our unseen guests" of a higher degree. This completes and sanctifies the oneness.

Those who have received the conception of a Divine Lord who is not merely omniscient "consciousness' but *Divine Man*—complete, organic, infinitely perfect, infinitely loving and creative as no finite image ever can be—will not abandon this for a less perfect "philosophy." But the summing up in the one word "service" disarms criticism; and when "Stephen" in his concluding message, thanking his two earthly friends for their patient work, says: "This, the banishing of fear, is what I want to do for others besides yourselves; this is why in the hour of earth's hideousness, I was allowed to tell you these truths."

We are of the opinion that the end in view atones for any imperfection in the message.

That the subjects treated of in spirit communications are a reflex of what is already in the minds of their receivers is beyond question. "Stephen's" friends, who serve as his amanuenses, disclaim all previous knowledge of such a philosophy as his; yet it is obvious that their modes of thought had already much that was in common. An even more notable example is the message received through Mrs. Houts which reflects the knowledge of the spirit world which the amanuensis already had from reading Swedenborg. This very notable work, *Voices From the Open Door*, (The Open Door Publishing Co., 1449 Willard Street, San Francisco, Calif.) is published anonymously, but the "Narrator" is understood to be the widow of Rev. Thomas Franklin Houts, a minister of the New Church.

This much is known about the Narrator. She is not a Spiritualist, nor is she a medium in the ordinary sense, but simply a clairaudient whose spiritual hearing has been opened, who listens to the spirit voices of her husband and brothers, as well as to the experiences of others who are passing through their Judgment in the Intermediate World of Spirits.

One who knows her says: "Some years ago an intelligent and spiritually minded woman, about sixty-five years of age, heard voices addressed to her inner ear. She wrote down what was said to her, without any rule or plan as to the use of such a record. After some years some of her friends advised the publication of her manuscripts. The author states: "It had for many years been my custom to devote thirty minutes in the morning of each day to quiet thought and reading of the Sacred Word and what would make its meaning clear and practical; also hymns and selections that gave expression to the wants and longings of my heart."

"It was while thus engaged that I became conscious of a companionship close and sympathetic, which grew more and more distinct, until I felt that my presence was recognized and made welcome. I could hear from within the songs of praise and join in the Lord's Prayer, and also at times hear parts of discourses. At the close of worship I have been spoken to by my husband and brothers who had not been many years in the spiritual world. I have also by request made through them, conversed by appointment with others. While I was the recorder of the narratives published under the title, *Voices From the Open Door,* I was no more under a "control" of any kind than is any person who in freedom and the use of all his faculties converses with friends and acquaintances, and records the subjects of the discourse.

"Both brain and hand were in perfect freedom. Nothing was written that was not clearly apprehended by me. There was never shown any disposition to intrude the presence of any one, nor to interfere with duties on the earth-plane. The time given to such conversation and writing was usually less than half an hour."

Rev. Charles H. Mann, former editor of the New-Church Messenger, says of this work: "In these voices the spiritual world conditions, and the laws there prevailing, and the laws of righteous living here, are almost the sole subject of treatment; in them there are some of the best statements of spirit-world laws of life that can be found outside of Swedenborg."

SWEDENBORG AND THE "FOURTH DIMENSION"

Recently I have alluded in the New-Church Review, and elsewhere, to Swedenborg's statements concerning the superspace of the spiritual world, which show that it is of more than three dimensions. I am not speaking of Einstein's "fourth dimension," which is obtained by making time a fourth co-ordinate; because the spiritual world is not conditioned by time any more than it is by natural space. Subsequently to Swedenborg, Kant speculated on the possibility of space having more than three dimensions; but Swedenborg's statements were founded on observation and were not the result of vague surmise. After Kant, the subject of dimensions was treated quite extensively by Riemann, Gauss and various other mathematicians.

To illustrate: If we have a number of objects contained in a perfectly continuous hollow sphere, such as a glass globe which has been blown, and then, after charging, has been melted off in the flame, they can not be removed under the laws of tridimensional space without breaking the sphere. But if space has a fourth dimension, the interior of the globe is entirely open in this direction, and the objects can be removed or replaced in the unbroken globe. It is not necessary that we should comprehend *how* this can be. We are perfectly certain of the existence of many things which we do not understand at present. It is all a matter of evidence.

About the middle of the 19th century, Professor Robert Hare of the University of Pennsylvania, a distinguished chemist and physicist, the inventor of Hare's deflagrator and other apparatus, devised an instrument which he named a "spiritoscope," in which spirit messages, obtained through a medium, were indicated by the motion of an index, so arranged that these motions were wholly concealed from the medium and were visible only to the recorder. Dr. S. A. Peters of Missouri, while on a visit to Philadelphia, witnessed the following experiment, which he described as follows in a letter addressed to the editor of The Spiritual Telegraph, dated April 18, 1858: "Dr. Hare, the medium (a young man named Ruggles, of from eighteen to nineteen years, to whom I was quite a stranger when I entered the laboratory), and myself, were the only persons present. The medium sat down in front of the *spiritoscope,* which stood on the table in the middle of the room. Dr. Hare and I sat opposite and close to the table. After some minutes it was said to us through the spiritoscope, 'Let Dr. S. A. Peters put two glass tubes and two pieces of Russian metal in the box.' Dr. Hare thereupon left his seat, and fetched me two glass tubes of about six inches length, and half an inch diameter, hermetically sealed at the ends, and also two pieces of Russian platinum, each of the shape of a common musket-ball. I first examined the box in which I was to deposit these objects. It stood on the table before me. It resembled a writing-desk; was about two feet long and half a foot broad, four to eight inches deep, and had a lid which let down slantwise, with hinges and a lock. In this box I placed the two glass tubes and the balls of platinum—there was nothing else in it,—and locked it. Dr. Hare and I then took our seats as before, and the medium, Mr. Ruggles, continued at the spiritoscope. After a lapse of fifty-five minutes there was said through the spiritoscope, 'We have a present for Dr. S. A. Peters; let him go to the box and fetch it.' Hereupon I went to the box, which was only a single foot from me, opened it, and found—*the two pieces of Russian platinum inside the two hermetically sealed glass tubes.*

"I will make no observation on the above. What I have seen I hold it to be my duty to make known to the world. I have no other interest in making the above statement than the desire to serve my fellow-men.

S. A. PETERS."

A great variety of phenomena, all different, but all demanding for their explanation the existence of a space of more than three dimensions,—are on record in the annals of psychical research. Perhaps few of the experiments have been as carefully guarded against possible fraud as the above:—the box locked and placed on the table immediately in front of the observer, all the time within a foot of him, with the medium on the other side of the table. Dr. Peters also writes with the precision of a careful observer.

The experiment in Professor Hare's laboratory could be explained in either of two ways:—*a*, on the supposition that the bonds of attraction between the molecules of the glass

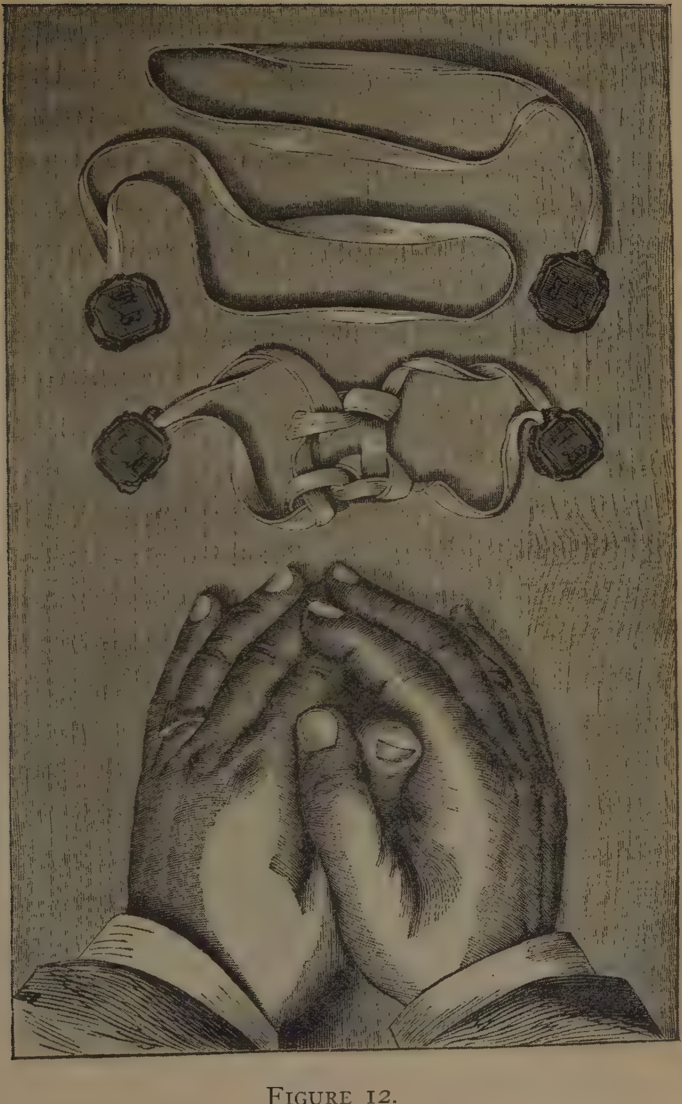

FIGURE 12.

have been temporarily released, and then have been restored after the insertion of the platinum pieces; or, *b*, as above noted, the transaction may have been accomplished through a fourth dimension of space, which is unperceived by us, but in which discarnate spirits carry on their ordinary activities. Professor Zöllner, who refers to the preceding experiment in his *Transcendental Physics,* has devised and conducted, with the indispensable aid of a medium, Mr. Slade, and the attendant discarnate spirits, an entirely different experiment which definitely decides in favor of the second explanation. He says (*op. cit.,* p. 81):

"I took two bands cut out of soft leather, 44 cm. long, and from 5 to 10 mm. broad, and fastened the ends of each together, as formerly described with the cords, and sealed them with my own seal. The two leather bands were laid separately on the card-table at which we sat; the seats were placed opposite to one another, and I held my hands over the bands (as shown on Plate II). Slade sat at my left side, and placed his right hand gently over mine, I being able to feel the leather underneath all the time. Slade asserted that he saw lights emanating from my hands, and could feel a cool wind over them. I felt the latter, but could not see the lights. Presently, while I still distinctly felt the cool breeze, and Slade's hands were not touching mine, but were removed from them about 2 or 3 dm., I felt a movement of the leather bands under my hands. Then came three raps in the table, and on removing my hands the two leather bands were knotted together. The twisting of the leather is distinctly seen in Plate II (copied from a photograph and reproduced here in Fig. 11.) The time that the bands were under my hands was at most three minutes."

This experiment in which leather bands have been inextricably intertwined in a fashion which it is impossible to produce in tridimensional space without cutting the bands, but which is perfectly feasible in four-dimensional space, was especially devised by Professor Zöllner as a test of his four-dimensional theory which it completely confirms. The twisting of the bands was foreseen by the theory. The preservation and photographing of the enmeshed bands guarantees the genuineness of the phenomenon. The experiment was performed in a well lighted room and under circumstances in which any direct interference by the medium was impossible. Other experiments in some of which Professors Fechner, W. Weber, and Scheibner, of the University of Leipsic, were present, gave further confirmation of the theory.

Now Swedenborg has told us many things about the appearances of space in the spiritual world, which in some respects are so similar to what is seen in the world of nature that no difference would be noticed, until attention had been drawn to certain bizarre phenomena, so extraordinary that it is necessary for him to say that the spiritual world is not in space, that is, not in space of three dimensions. The superspace of the spiritual world is, in fact, separated from the space of nature by a discrete degree of which Riemann treats in his mathematical theory of dimensions.

"In the spiritual world there are not determinate quarters, as in the natural world, but they are determined by the direction of the face." (H. H., n. 123.) Thus "the east is always before the angels, the west behind them, the south on their right, and the north on their left; but since this can not be easily understood in the world, because man turns his face to every quarter, therefore it shall be explained.

"The whole Heaven turns itself toward the Lord as to its common center; hence all the angels turn themselves thither.

That there is also a universal tendency on earth to a common center, is well known; but the tendency in Heaven differs from that in the world. In Heaven the front parts tend to the common center, but in the world the lower parts. The tendency in the world is called centripetal force, and also gravitation. The interiors of the angels are also actually turned forward; and because the interiors present themselves in the face, therefore the face is what determines the quarters.

"But that the angels have the east before them *whithersoever they turn their faces and bodies,* is something still harder to understand in the world, because man has every quarter before him according to the direction in which he turns himself. Therefore, this also shall be explained.

"The angels turn and bend their faces and bodies in every direction like men; but still they have the east constantly before their eyes. But the changes of aspect with the angels are unlike those of men, and are from another origin. They appear similar, indeed, but still they are not, because all determinations of aspect both with angels and spirits result from the ruling love. For, as was said just above, their interiors are actually turned toward their common center, thus in Heaven toward the Lord as a sun. Wherefore since the love is continually before their interiors, and the face exists from the interiors,—for it is their external form,—therefore the ruling love is always before the face. Hence, in the Heavens, the Lord as a sun is continually before them, because He is the source from which they derive their love; and since the Lord Himself is in His own love with the angels, therefore it is He who causes them to look to Him in whatever direction they turn." (H. H., nn. 142, 143.)

The subject is further elucidated in what Swedenborg tells us in regard to "time" and "space" in Heaven; but the foregoing will be sufficient to show that the results of Zöllner's researches are no more extraordinary than those made known to us through Swedenborg's experience. The two appear to be diverse phases of a single fact seen from opposite sides;—they are inexplicable marvels to one whose thought is bounded by things of space and time; but, seen spiritually, they are both comprehensible and also inevitable.

In an article in the American Magazine for October, 1920, Dr. Thomas A. Edison is quoted as being of the opinion that "the degree of material or physical power possessed by those in the next life must be extremely slight." Hence any material instrument designed for their use must be "super-delicate—as fine and responsive as human ingenuity can make it." And he proposes to try to perfect such an instrument of which he says: "If those who have left the form of life that we have on earth can not use, can not move the apparatus that I am going to give them the opportunity of moving, then the chance of there being a hereafter of the kind we think about and imagine goes down." In other words, Mr. Edison proposes to set himself up as a referee on the old, old question: "If a man die, shall he live?" If his machine does not work, that is, if the spirits are unable or unwilling to use it, why, that settles the matter. There is no hereafter!

Let it be noted in respect to this extraordinary proposition, that the spirits already have, in the brains and bodies of certain somewhat peculiar individuals known as mediums, intruments of a finer construction than any which human ingenuity can hope to duplicate. And as to the power, the following experiment is sufficiently explicit:

Professor Zöllner tells us that "on the occasion of Slade's first visit, on the 16th of November, 1877, in my house and in the presence of my friends and colleagues, Wilhelm Weber and Scheibner," there occurred with a starting noise, resembling that of the discharge of a large battery of Leyden jars, "the sudden rending of the wooden frame of a bed-screen at least five feet from Slade." By computation from the known strength of material, it was found that the logitudinal pull in opposite directions, necessary to produce this rupture, must have been something like 198 cwts., and at least ten times as much as a man of Herculean strength could exert. The spirits evidently do not lack for strength.

"That Angels possess power, cannot be conceived by those who know nothing of the spiritual world and of its influx into the natural. They suppose that the Angels cannot have any power because they are spiritual beings, and of so pure and unsubstantial a nature that they can not even be seen by the eyes. But they who look more interiorly into the causes of things, think differently; for they know that all the power of man is derived from his understanding and will, since he can not move a particle of his body without them. The understanding and will are his spiritual man. This sets in motion the body and its members at pleasure; for what this thinks, the mouth and tongue speak; and what this wills, the body executes,—to which also it gives strength at pleasure. The will and understanding of man are ruled by the Lord through the instrumentality of Angels and Spirits; and therefore all things of the body are ruled in like manner, since these are from the will and understanding; and, incredible though it may seem, man can not stir a single step without the influx of Heaven." (H. H., n. 228.)

The phenomenon described by Zöllner would savor less of angelic presence than of the spirits controlling the demoniac of Gadara who "had been often bound with fetters and chains, and the chains had been rent asunder by him, and the fetters broken in pieces; and no man had strength to tame him," (Mark, V, 4), were it not that Slade's spirits apologized and said that they had not meant to do harm. I do not know how the thing was done, but it certainly looks as though the spirits were able to control the energy which underlies the innermost movements of the atoms and which must be enormous. The revealing of the hidden powers of the radio-active elements has demonstrated the existence in matter of latent forces of this order.

Hypnotic hallucination is supposed to be the explanation of certain startling exhibitions by Hindoo fakirs, which, though the deception could not be discovered by the eye, were not confirmed by photography. This is not the case with some of the phenomena exhibited under mediumistic control in recent experiments of psychical research, where photographs have demonstrated that levitation, and such procedures as the emission of a luminous substance from the abdomen, mouth, or neck and shoulders of a medium, can occur and be recorded by an absolute unbiased instrument. This eliminates all chance of hallucination.

THE "LIMBUS"

Many years ago, the late Sir William Crookes obtained evidence that a considerable amount of force could be exerted on the pan of a balance by some emanation proceeding from the body of a medium under spirit control, as had previously been demonstrated by Hare. J. D. Beresford's paper, "A New Form of Matter," in Harper's Magazine for May, 1919, pages 803 to 816, may be consulted for a summary of these more external phenomena of a material substance, derived from the human body, which is intimately controlled by man's spirit. (See also the final Section of this Chapter.) The majority of these effects require the manipulation of this plastic substance by disembodied spirits. It seems to be the substance out of which are produced "materializations" of spirit forms.

It is also possible that some of the phantasms of the dead, for which fairly good evidence is adduced by psychical research, can be produced without a medium; for Swedenborg tells us that "after death . . . man retains the Spiritual from the father, together with a certain limbus from the purest things of nature around it; but with those who come into Heaven this limbus is below and the Spiritual is above, whereas with those who come into Hell this limbus is above and the Spiritual below." (T. C. R., n. 103). In "Divine Love and Wisdom," we are told that "man's natural mind consists of spiritual substances together with natural substances; thought comes from its spiritual substances, not from its natural substances; these recede when the man dies, while its spiritual substances do not. Consequently, after death, when man becomes a Spirit or Angel, the same mind remains in a form like that which it had in the world. The natural substances of that mind, which recede, as was said, by death, constitute the cutaneous covering of the spiritual body which Spirits and Angels have. By means of such covering, which is taken from the natural world, their spiritual bodies maintain existence; for the Natural is the outmost containant; consequently there is no Spirit or Angel who was not born a man." (n. 257.) "He who is acquainted with the quality of substances in the spiritual world, and with the respective quality of matters in the natural world, may easily see that there is not given any procreation of angelic minds, except in those and from those who inhabit the earth, the ultimate work of creation;

but whereas it is unknown what the quality of substances in the spiritual world is in respect to matters in the natural world, it shall now be declared. Substances in the spiritual world appear as if they were material, therefore they are not constant, being correspondences of the affections of the Angels, and being permanent with the affections of the Angels, and disappearing with them. Similar would have been the case with the Angels if they had been created there; but, moreover, with the Angels there is not given, neither can be given, procreation, and thence multiplication, except what is spiritual, which is that of wisdom and love, such, also, as is that of the souls of men who are generated anew or regenerated; but in the natural world there are matters by which and from which procreations, and afterwards formations, can be effected, thus multiplications of men, and thence of Angels.

"That Spirits and Angels hence derive a capacity of subsisting and living forever. The reason is, because an Angel and a Spirit, in consequence of being first born a man in the world, derives subsistence; for he derives from the inmost principles of nature a medium with himself between what is spiritual and what is natural, by which he is bounded to subsistence and permanence, having relation by the latter to those things which are in nature, and having also a principle corresponding to those things; hereby also Spirits and Angels can be adjoined and conjoined to the human race; for there is a conjunction, and where conjunction is there must be a medium." (*Concerning the Divine Wisdom*, n. viii.)

These statements in respect to the limbus will be found to contain the basis of a complete explanation of the phenomena described by Beresford. One can not help comparing and contrasting the method of Swedenborg with those of psychical research. Swedenborg's experience is that of the internal man, received through the exquisitely sensitive spiritual senses which are far more active and vivid than those of the natural body, and which include the indefinitely varied phenomena of the spiritual world. His thought derived from spiritual experience is extraordinarily profound. Into one of his paragraphs, indeed sometimes into one of his sentences, there is condensed more meaning than would be found in many pages of ordinary writing. And even then he tells us that what he writes is very imperfect compared with the richness and fulness of angelic thought, because natural language is not competent to compass angelic thought. Interior thought penetrates to realities and includes innumerable details.

THE QUESTION OF THE PERMISSIBILITY OR DESIRABILITY OF PSYCHICAL INVESTIGATIONS BY THE MODERN ROAD

I have spoken of the painful laboriousness of the methods of psychical research. After gathering numerous examples of the special phenomenon to be investigated, these have to be thoroughly sifted and valued. From their combination and discussion under various tentative hypotheses, there at last emerges a somewhat dubious inference, which is to be compared with some one of Swedenborg's minor statements; but the latter are found to be supported by innumerable cross-references binding the whole together into a structure of such strength that it can not be overthrown. That some, perhaps even most of the few inferences which psychical research considers itself competent to draw, are confirmatory of what Swedenborg teaches is interesting; but that knowledge obtained under such unfavorable conditions is comparable in value to his first-hand unfoldings of the complete laws of the spiritual realm, can not be admitted. We do not say this to discourage these gropings, but to give them their true place. The neglect of Swedenborg's psychical experiences on the part of psychical research and the unwarranted confounding of them with the ordinary are regrettable defects.

I think we may say that these recent results of psychical research, while they do not approach the voluminous and varied records of Swedenborg's experience, do, nevertheless, bring a confirmation of some of his statements which many people will feel to be desirable; and nowhere is there disagreement, except as to the meaning of these things. But here Swedenborg's explanations from fuller light are far and away superior to the vague surmises and hypotheses which pass for explanations with many. Under the new name of the "subconscious" is included much of what he tells us about the internal memory. He also tells us facts concerning obsession of human beings by devils. Under the new name of "divided personality," psychical resarch vouches for similar things. Sir William Barrett, however, who stands almost alone in doing justice to Swedenborg, restores the name of obsession to such cases. Swedenborg teaches that we should not be led by the opinions of spirits, and I would not for one moment advocate the acceptance of anything from that source, except on its merits, and where it can be shown to be not subversive of well recognized spiritual truth. As confirming more reliable information, the things made known by psychical research are not without interest.

Especially is it of interest to find that the World of Spirits is gradually coming into a more orderly condition. While our societies for psychical research are breaking ground on this side, it appears that there are societies in the World of Spirits which are laying the foundation for a more perfect control of the means of communication by the heavenly powers. Hereward Carrington in his book, *Psychical Phenomena and the War,* narrates the following as having occurred in his circle of friends:

"A young girl whom we will call Heather, is affianced to a brave young soldier. He leaves his love and his country and yields up his life on the great sacrificial altar of the battlefields of France. When Heather hears the news, she is distracted, overwhelmed. Then she learns that spiritual communion is possible, and by chance, she is brought in contact with a sensitive who sees and describes to her her soldier lover. Soon she is invited to sit in a small spiritual circle, and to her surprise she becomes clairvoyant and clairaudient; that is, she sees those who have passed through death's portals, she hears their voices, and for her there is a new heaven and new earth; former things have passed away—she has not lost her lover, death has not divided hem. The consciousness of his presence lifts her heart nd soul above the things of earth; she is still his and he s hers, and these two know that they are one forever, that heirs is a marriage made in heaven, which the cold blasts of earth can never chill, and now Heather looks forward to he day when her lover and herself shall work together in he great spiritual harvest fields, and shall do such work as they might never have accomplished had he remained in he physical body. Daily he visits her now and informs her how he attends lectures at the halls of learning, and studies n the colleges in the Great Beyond and how one of the pecial subjects he is learning, and graduating for, is the ifferent methods of controlling earth mediums and the ways of efficiently guarding them from obsession." (p. 259-60.) One has to admit that such occurrences must be very exceptional, and as both parties have life's lessons yet to learn in their different spheres, one would expect the association to be only temporary.

No one can deny the great need of circumspection in approaching spiritistic phenomena. We must be continually on our guard against deception; but taking this account at its face value, it suggests that possibly the dangers of communication with spirits may be somewhat alleviated by the appointment on the spiritual side of a system of guards—a sort of spiritual police—and that in the interest of a renewed faith in immortality, a certain measure of permitted intercourse is to be restored. Primitive man tamed the wolf and from that conquest gained a helper in the dog. So evil can be made to serve, if it will, and in serving may receive a certain measure of salvation.

Swedenborg tells us that ignorance of the life after death is a cause of doubt concerning the Divine Providence. "The reason men have not known it, is that with those who do not shun evils as sins there is interiorly a latent belief that man does not live after death. . . . But with all in whom there is any religion the Knowledge is implanted that men live after death." (D. P., n. 274.) "To those who believe (that they have a spirit which will live after death), the other life is the all of their thought and affection . . . But to those who do not believe it, the world is the all of their thought and affection, and the other life is relatively nothing. The former are those who can be regenerated; and the latter are those who can not." (A. C., n. 2682.)

If the need of a restored faith in immortality is as great as these passages indicate, may we not look for, yes, welcome intercourse with the spirit world which is justified by its results?

In deciding this question, and in view of the terrible consequences of demoniacal possession, we would point out that intercourse with spirits should not be sought. When it comes unsought, the criterion of the Apostle John should be applied: "Beloved, believe not every spirit, but prove the spirits whether they are of God; because many false prophets are gone out into the world. Hereby know ye the Spirit of God: Every spirit that confesseth that Jesus Christ is come in the flesh is of God; and every spirit that confesseth not Jesus is not of God." (First Epistle of John v, 1-3.) In any case, we are to have no dealing with "famliar spirits." (Leviticus, xix, 31.) The spirits who desire o become "familiar" with us and to enter into the interior hings of our memories and possess them, are devils. Angels never do this. But the Sacred Scriptures are full of ecords of messages received from angels who are messengers of God. We can not turn away these authorized communicants.

The case is different with professional mediums. The New Church strongly advises the shunning of such methods of intercourse with the spiritual world. We ought, howver, to know enough about these things to understand them n order to protect the innocent whenever we are called pon to do so. Much of the information contained in pirit-communications through mediums is simply trancribed from the internal memories of the sitters (their soalled "subconscious minds") which are an open book to he control. While such mind-reading on the part of the pirits may be surreptitious and is apt to be used for puroses of deception, such as fraudulent impersonation, it not fair to assume that all such communications are inended to mislead. Some of them are obviously meant to e helpful. "Stephen" in "Our Unseen Guest" appears to e honest. He explains that one of the difficulties which the would-be communicating spirits meet, is the strong tendency for the subconscious mind of the percipient to irrupt and to produce meaningless or fragmentary discourse. The communicator must be something of an expert to prevent such interruptions. Not all can accomplish the feat. Evidently, "mediums," or intermediates who have acquired the art, are required on the other side of the veil as well as on our side, though their function differs from that of the earthly medium. The one is a sending instrument, the other a receiver.

Moreover, mediums have frequently been accused of deliberate fraud, where, on the contrary, they have themselves been the victims of ignorant experimenters who have insisted on interfering, not recognizing that a medium is like a very delicate galvanometer, whose indications may be wholly false unless certain precautions are observed. Sir William F. Barrett in his work, *On the Threshold of the Unseen,* says (p. 123): "Mediumship depends on the emergence of the subconscious life and therefore the ordinary waking consciouness must be more or less passive. It is the lack of the normal conscious control of his thoughts and actions that renders the medium liable to the influence of any inimical suggestion from the sitters. For a medium is eminently a *suggestible* subject, and may sometimes unconsciously be the victim, and not the conscious originator of the fraud which dominates the opinion of those sceptical investigators who believe that all mediums are imposters."

The case of the medium, Slade, accused of fraud and penalized in a court of law on biased testimony, with refusal of the court to hear witnesses who were ready to testify on the other side, is probably such an instance; for the thoroughly scientific investigations of Zöllner subsequently demonstrated the genuineness of Slade's mediumship.

Professor Barrett notes that "confused results are obained in psychical research, especially by those who fancy he sole function of a scientific investigator is to play the art of an amateur detective; and accordingly what they etect is merely their own incompetency to deal with the roblems the very elements of which they do not understand nd seem incapable of learning." (*Op. cit.*, p. 121.)

If the advice of this eminent student, who is one of the ounders of the British Society for Psychical Research, ere heeded, there could be little harm from such questionng as he recommends. He says (Preface, p. xviii): "Those ho like St. Thomas can not believe in survival after bodily eath, without some material demonstration, will probably ind in continued sittings with one or two friends in the anner described in Appendix D, a response to their yearnings and an aid to their faith. Having attained this assurance I do not advise them to pursue the matter further, but ather learn more of the spiritual world and spiritual communion from the Christian mystics of all countries! especially would I commend a book by the late Mr. J. H. Spaulding,* where the teaching of that gifted seer Swedenborg is luminously and dispassionately set forth."

This guarded approval of certain phases of spiritism with due recognition of the dangers of the quest, is to be preferred to Sir Oliver Lodge's position (with its almost complete ignoring of Swedenborg) in his *Survival of Man,* hich I have criticised in the New-Church Review for uly, 1910. For us, the divinely permitted experience of Swedenborg is of far more value than any mediumistic xperiments. But note Sir William Barrett's warning to ceptics: Having convinced yourself that there is such a hing as spirit communication, *drop it!*

It would be a dreadful mistake to assume that the intermediate World of Spirits—the *Judgment* world, where good is being separated from evil—can instruct us in the supreme truths we need to know. The spiritual state of that world is a continuation of that which prevails in this world at any given epoch. Today, a vast multitude of the newly arrived discarnate spirits in that psychic world, trust in their own perverse and deluded ratiocinations. They did so in this world, and by no magic can they be instantaneously changed They are essentially heathen. They worship the great god Pan and his troop of satyrs,—the persuasions and lusts of the proprium which continually suggest: "Ye are gods."

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* **The Kingdom of Heaven as Seen by Swedenborg.**

In our business world, Pluto, god of wealth, is still worshiped extensively, and idolatry survives in the adoration of saints in Romish Babylon. The worship of Mammon is the very essence of Babylon—the desire to be greatest and to rule over all. With the intellectually inclined, this desire takes form in "philosophies" which strive to overthrow the Divine and to substitute pantheistic schemes which imagine futilely that the lower can produce the higher. Vain projects! destined to vanish away, when the Power of the Lord in His Divine Humanity becomes manifested.

In regard to one other psychical phenomenon—that of death-bed experiences—I will quote the following lucid statement by the Rev. John Whitehead:

"We have been asked to give our view and that of Swedenborg toward what may be called spontaneous psychic openings. That is, toward psychic experiences which come to people without any seeking for it on the part of the percipient. Of such experiences we may mention death-bed experiences. [The case of Daisy Dryden is a notable one.]

"Often a person near to death will have a vision of a near relative who has passed into the spiritual world some time before. These are typical cases of spontaneous psychic openings. Are they the sight of the actual persons now living in the spiritual world; or are they hallucinations due to a deranged condition of the brain or to a super-sensitive imagination?

“Our answer to this question is that they are undoubtedly the actual sight of the real persons who are in the spiritual world. One proof that they are not due to a disordered imagination is that the person is in a normal condition when suddenly the person [of the disincarnated spirit] is seen, most vividly, making an extraordinary impression, oftentimes with a very distinct message, and producing a strong conviction of the actual presence of the persons and of the reality of the life after death.

“In the case of distorted and diseased imagination such as that of insane people, the visions are confused, incoherent and distorted. But these [death-bed visions] are clear with a definite end of preparing one for the change about to be made. Moreover, those present receive an extraordinary impression of the reality of the experience. The vision is not only convincing to the one who has the experience, but also to all present. A remarkable change is seen in the percipient which deeply impresses all beholders.

“These and other similar experiences are often called hallucinations because there is no material presence. This use of the term hallucination is undoubtedly unscientific, for the term means an impression not made by any real object; but there is a real spiritual object which makes the impression. This impression is not made upon the sense organs of the material body, but it is an actual impression upon the sense organs of the spiritual body. The person seeing the vision is for the time being an actual conscious percipient of those who are in the spiritual world, and he sees by the same sight which he will exercise when he is released from the connection with the material body. In fact at the time these experiences usually come, there is a preparation going on for the release of the spirit from the body. Why then are there not many cases of the opening of the spiritual senses to perceive the things of the spiritua world? We believe there are many such cases. Other forms of spontaneous openings come under similar laws. These are for important uses in giving evidence of the reality of the spiritual world."

Swedenborg says: "There are few who believe they are to live after death, and on this account also heavenly things are of no value to them." (A. C., n. 5006.) This was so in his day, and it is perhaps doubtful whether there is much genuine belief in immortality even now, or whether anything beyond hypotheses and hopes would be found if we could get at the real opinions of people. Hence the restoration of a belief in a life after death should at least have this effect: That it will cause heavenly things to be better appreciated, and therefore more sought after. We are assured that the former prevalence of the false belief in the resurrection of the *material* body was "attended by this use—that they believe in the life after death." (A. C., n. 10,758.) And now that even this slight hold on immortal life has departed with large numbers of the more intelligent, the prevalence of such disbelief in immortality constitutes one of the chief reasons for the nonacceptance of the New Church and its teachings.

We are told that "speech with the dead would produce an effect like that of miracles . . . But this happens only when the Spirits bring in something dogmatic of religion, which is never done by any good Spirit." (D. P., n. 134 a.) But we are also told that sometimes such speech is granted.

In what does the criterion of permission consist? Doubtless it is not truly necessary at the present time that we should know more about the life to come than what is revealed in the divinely authorized work, *Heaven and Its Wonders and Hell. From Things Heard and Seen.* If more is desired, the gate of dreams is always open for those who are willing to learn the correspondential language of the dream life. Nevertheless, because there are some who can not be reached in this way and yet need to have their waning faith in immortality resuscitated, there are permissions, such as the publication of books like *Our Unseen Guest, Fear Not the Crossing,* etc., which have their use.*

With the great growth of interest in what pertains to immortal life which has been going on for a generation, culminating in the work of our psychical-research societies, there comes today the great opening produced by the sudden entrance into the spirit world of millions of young men, slain in the Great World War, taking with them a vivid interest in the world which they have left behind, and constituting a vast intermediate society and focus of endeavor to uplift the world and to complete the overthrow of the Dragon, after they shall have been formed into harmonious gyres. They have gone in the full flush of youthful valor to follow the glorious Rider on the White Horse "out of whose mouth goeth a sharp sword that with it He should smite the nations." And in that terrible nine-days' retreat from Mons, when the flower of the British Army, as well as of the French, yielded up their lives amid scenes of terror, there appeared before the eyes of the dying that wonderful vision of the Angels of Mons, stemming the ebb-tide of retreat and turning despair into elation and "a singular state of exaltation*" in the survivors, as one narrator puts it. Like the servant of Elisha, their eyes had been opened, and they had seen the mountain full of "chariots of fire round about Elisha," until, like Elisha at the passing of Elijah, they were ready to exclaim: "My father, my father. The chariots of Israel and the horsemen thereof."

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* A book called "The One Way" by Mrs. Jane Revere Burke (New York: Privately Printed, 1921) which purports to contain a message from the spirit of the late Professor William James, is of interest as a specimen of spiritistic literature. While a large part of this book inculcates religious principles of a high order, there are subtle suggestions of an entirely opposite sort and all the more dangerous on account of their pious setting. We are advised: "Don't make so sure that automatic writing is some fearful new invention of the devil and so drive the truth which should be within the historic Church outside it." The medium is implored to "be willing to be led by us." And we are exhorted to abandon reason and be led by "instinct" and spirits. There is an effort to break down the distinction between God and man: "You are a part of God the Father;" also an effort to override the Biblical prohibitions of illicit spirit intercourse, and to suggest that keeping the commandments is not so absolutely essential: "What is known to you as a deathbed repentance is, thank God, very common." Moreover, certain presumably still more "deterrant" suggestions have been suppressed by the medium herself. We seriously doubt the sincerity of these would-be spirit-guides. We shall say nothing here of the even more openly and demoniacally blasphemous and immoral suggestions with which a certain sort of spiritistic literature teems.

SECTION B

SWEDENBORG'S "CLAIRVOYANCE"

Wherein is it distinct from and where, possibly, does it coincide with the experience of others? Swedenborg's experience unique in most respects. Neither a Thaumaturgist nor a Spirit Medium.

Among various incidents in Swedenborg's life which belong to the category sometimes described as "clairvoyance," "second-sight," "the prophetic gift," etc., the following may be selected:

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*Compare "On the Side of the Angels." A Reply to Arthur Machen. By Harold Begbie, London: Hodder and Stoughton, 1915.

"The Prince of Prussia was brother to the Queen of Sweden, and shortly after his death, Swedenborg being at court, the Queen perceiving him, said: 'Well, Mr. Assessor, have you seen my brother?' He answered: 'No;' whereupon she replied: 'If you should see him, remember me to him.' In saying this she did but jest. Eight days afterwards, Swedenborg came again to court, but so early that the Queen had not left her apartment, where she was conversing with her maids of honor and other ladies of the court. Swedenborg did not wait for the Queen's coming out, but entered directly into her apartment and whispered in her ear. The Queen, struck with astonishment, was taken ill and did not recover for some time. After she was come to herself, she said to those about her: 'There is only God and my brother who can know what he has just told me.'" The thing being noised abroad, for days thereafter there stopped before the door of the seer carriages from which the first gentlemen of the kingdom alighted, desiring to learn the secret, which Swedenborg very properly refused to tell.

J. H. Jung Stilling tells this story: "A merchant of Elberfeld of his acquaintance called upon Swedenborg while the latter was residing at Amsterdam, in 1770, and found a very venerable-looking, friendly old man, who received him politely, and requested him to be seated. Explaining his errand and expressing his deep admiration of Swedenborg's writings, he desired that he would give him a proof of his intercourse with the unseen world. Swedenborg said: 'Why not? Most willingly.' The merchant then proceeded to tell that he had formerly a friend, who studied divinity at Duisburg, where he fell into a consumption, of which he died. Visiting this friend a short time before his decease, they conversed together on an important topic. The question he then put to Swedenborg, was: 'Can you learn from the student what was the subject of our discourse at that time?' Swedenborg replied: 'We will see; what was the name of your friend?' The merchant told his name, and Swedenborg then requested him to call in a few days. Some days after, the merchant went again to Swedenborg in anxious expectation. The old gentleman met him with a smile and said: 'I have spoken with your friend; the subject of your discourse was *the restitution of all things.*' He then related to the merchant, with the greatest precision, what he, and what his deceased friend, had maintained." The merchant was almost as much astounded as had been Queen Louisa Ulrica, and learning that his friend still continued to torment himself with the idea of the restitution of all things, he exclaimed: "My God! What, in the other world?" Swedenborg replied: "Certainly, a man takes with him his favorite inclinations and opinions, and it is very difficult to be divested of them; we ought therefore to lay them aside here." There are other analogous cases, and yet others where the request was refused because actuated merely by an idle curiosity.

The next incident is related by the philosopher, Immanuel Kant, who, though strongly prejudiced against the supposition of anything being known except what the senses reveal, and also having been guilty of ridiculing Swedenborg, was compelled by the overwhelming evidence to acknowledge the truth of this narrative. He says:

"In the year 1759, towards the end of July, on Saturday at four o'clock P. M., Swedenborg arrived at Gottenburg from England, when Mr. William Castel invited him to his house, together with a party of fifteen persons. About six o'clock Swedenborg went out, and returned to the company quite pale and alarmed. He said that a dangerous fire had just broken out in Stockholm, in the Södermalm (Gottenburg is about three hundred miles from Stockholm), and that it was spreading very fast. He was restless and went out often. He said that the house of one of his friends, whom he named, was already in ashes, and that his own was in danger. At eight o'clock, after he had been out again, he joyfully exclaimed: 'Thank God! the fire is extinguished, the third door from my house.' The news occasioned great commotion throughout the whole city, but particularly amongst the company in which he was. It was announced to the governor the same evening. On Sunday morning Swedenborg was summoned to the governor, who questioned him concerning the disaster. Swedenborg described the fire precisely,—how it had begun, and in what manner it had ceased, and how it had continued. On the same day the news spread through the city, and, as the governor had thought it worthy of attention, the consternation was considerably increased, because many were in trouble on account of their friends and property which might have been involved in the disaster. On Monday evening a messenger arrived at Gottenburg, who was despatched by the Board of Trade during the time of the fire. In the letters brought by him the fire was described preiscely in the manner stated by Swedenborg. On Tuesday morning the royal courier arrived at the governor's with the melancholy intelligence of the fire, of the loss it had occasioned, and of the houses it had damaged and ruined, not in the least differing from that which Swedenborg had given at the very time when it happened; for the fire was extinguished at eight o'clock."

Throughout the life of this wonderful man we continually meet with incidents which are related of his power to foresee the future,—his foretelling the day and hour at which the vessel on which he was about to embark in London would arrive at its port in Sweden; his foretelling to Wesley the day of his (Swedenborg's) entrance into the spiritual world, never to return to earth, and so on.

These stories have been repeatedly quoted, but Swedenborg nowhere mentions these occurrences in his published writings and nowhere appeals to them as an evidence of his mission. They have been preserved and handed down to us by others, by eye witnesses of unimpeachable credibility, and were thoroughly investigated at the time; but he himself tells us that the new spiritual revelations are not to be supported by miracles, because these *compel* acceptance, whereas we are henceforth to be led in matters of belief in spiritual verities, in freedom and according to reason.

Yet these occurrences are of interest as showing that Swedenborg possessed what is sometimes called the "clairvoyant," or perhaps some would prefer to call it the "mediumistic" constitution, although his admission into the full use of *all* of his spiritual faculties and his uninterrupted continuance in the same for twenty-eight years,* until within a few days of his death, is absolutely unique. It should never be confounded with spirit-mediumship (although both experiences may be called supernatural), and constitutes in itself, an occurrence which surpasses all miracles. He has much to tell us of the results of this intromission into the spiritual world, but always as illustions of the laws of spiritual life, and not to base upon them a claim of superiority for himself, or to compel belief on rity. He would have us believe in the truth be- see that it must be so. Swedenborg's own account ritual state will be found in *Invitation to the New* n. 43, 44 and 52.)

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* In "True Christian Religion," n. 281, this duration is given as 27 years. The work was published in 1771, and Swedenborg lived one year after this, still retaining his privileges.

ral passages our author mentions that he was per- pass through experiences which would be called t, or mediumistic, including that of spirit-control; as simply that he might be convinced that there hings, that he might study them from experience learn their causes. His attitude towards these was that of the scientist who observes, describes, notes, and endeavors to arrive at philosophic con- ncerning the nature of observed facts. Those imagined that he is a speculative philospher are under a complete misapprehension.

GEORGE HOGGAN, M.D.
(Student under vivisector Bernard who baked live animals slowly to death):
After having related what I saw, it is not necessary for me to add that I am willing to let not [illegible] entire human race perish.

The nature of "clairvoyance" is still an open question. Some have looked upon it as a "sixth sense," capable of penetrating space and material barriers by perception of subtle vibrations in the ether, or something similar. Some would consider it to be a power of separating the limbus, or "astral body" from the physical body, and of projecting it through space. Yet others think that direct use is made of spiritual faculties and spiritual atmospheres above the plane of nature. Mrs. Grace Courtland has given us a very interesting account of such openings of the inner spiritual perceptions.* In the autobiography of this brave, good and generous woman she says: "I have one desire—that the readers of this book and the public do not confound me with the Spiritualists; I am not a Spiritualist, simply a Clairvoyante, and I make no attempt to explain the power given me." Nevertheless, her occasionally hearing the voice of her angel mother, and sometimes seeing her form (thus having her spiritual ears and eyes open), her ability to perceive the interior bodily infirmities of the sick and to restore them to health, the warnings which repeatedly saved her from impending dangers and the prognostications of coming events, are all of the sort of experiences which we should class as angelic visitations and prophetic inspirations which only the pure in heart can receive; and while wishing to keep an open mind as to the possibility of unknown vibrations in the atmospheres of nature, we believe that experiences of this sort in very many instances are communications received through opened spiritual senses by means of *spiritual* atmospheres, from attendant spirits of various orders. Some are accompanied by direct revelations from God through angels; others may be of less value, or even of misleading import and from deceitful spirits. We have treated of this in another part of this work, and will here only say that, with the fading of genuine belief in Christianity, there has come a recrudescence of Pagan practices. Once more, many of our people lean on the sayings of Pythonesses as in the ancient world. It is better to do this than to have no belief at all in a spiritual world and spiritual guardians, even if these beliefs are hardly lifted above the material plane; and in this resuscitation of the Pagan religion, we see a Divine permission, adapted to the needs of an atavistic world immersed in a materialistic philosophy.

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* "A Marked Life, or the Autobiography of a Clairvoyante," by "Gipsey." London: Sampson Low, Marston, Searle, and Rivington. 1879.

Of the ancient oracle of Delphi, Brevior says:* "That its decrees were reverenced, not only by the vulgar, but by philosophers and statesmen—that it was consulted by authority in all public emergencies—that it determined quesions of peace and war—the settlement of colonies, the ounding of states—that it influenced the fate not only of ndividuals, but sometimes of armies, and even of the state tself; and not only the destinies of Greece 'but more or ess that of all the countries around the Mediterranean,' so hat 'in all matters of importance, whether relating to reigion or to politics, to public or to private life,' the words f the entranced woman—the priestess of the oracle, a imple, unsophisticated country woman [goodness, not earning determining her choice] settled the disputes, and preserved and promoted the religion of the greater portion f the ancient world';—are all plain matters of history. We derive,' says Plutarch, 'immense advantages from the he favor the gods have conceded to her—she, and the riestess of Dodona, confer on mankind the greatest beneits both public and private. It would be impossible to numerate all the instances in which the Pythia proved the mportance of her power of foretelling events; and the facts f themselves are so well and so generally known, that it vould be useless to bring forth new evidence. She is second o no one in purity of morals and chastity of conduct. Brought up by her poor parents in the country, she brings vith her neither art, nor experience, nor any talent whatver when she arrives at Delphi, to be the interpreter of the od. She is consulted on any account,—marriage, travels, arvest, diseases, etc. Her answers though submitted to he severest scrutiny, have never proved false or incorrect. On the contrary, the verification of them has filled the emple with gifts from all parts of Greece and foreign ountries.' The same writer records that she predicted the errible eruption of Vesuvius that buried Pompeii and Herulaneum, and caused the death of the great Pliny." (pp. 2, 23.) Even if we have to make allowance for some exaggeration in these claims, there can be no doubt that the oracles of Greece were supernaturally controlled and that they maintained a connection between the spiritual and the natural worlds.

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* Thomas Brevior. "The Two Worlds, the Natural and the Spiritual." London: F. Pitman, 20 Paternoster Row. 1868.

In times of great national or individual calamities, God sends His messengers to comfort and sustain. The Maid of Orleans and her "Voices" come instantly to recollection. It was inevitable that this pure-minded being should be accused of dealings with devils. Did not Jesus say: "If they have called the Master of the house Beelzebub, how much more them of his household." (Matt., X, 25.) Swedenborg did not escape from the same aspersions. Dr. Maudsley in his "Body and Mind," instanced Swedenborg as an example of hallucination and insanity, in spite of overwhelming testimony to the contrary. The Rev. John Goddard has ably disproved the alleged defect. In his treatment of "Swedenborg's Supposed Hallucination," * he says

"The student of nervous diseases should be able to take up his works, and declare where the first symptoms of insanity were manifest. Not only this, but he should be able to make known the symptoms of its increase. For a disease of the brain, if it first developed at the age of fifty-six years (Swedenborg's age when he declared that the spiritual world was opened to him, and that he was called by the Lord to the office of a seer),—I say if brain disease developed thus early, and were not checked by treatment or by rest, what would be the result of the disease at the age of

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* The New-Jerusalem Magazine, Vol. XI. New Series, No. 9 September, 1887. Dr. Maudsley in the work cited, had rejected the testimony of Swedenborg's friends who knew him best and who loved and admired him, as being "biased" in his favor, and had published obvious slanders, which a little investigation would have shown to be either entirely false, or maliciously garbled.

eighty-three, the period of his death? The authorities on hallucinations tell us that its course is likely to be rapid. But, so far from having treatment or rest, the last twenty-seven years of his life were years of unremitting toil; for, during this period, he produced upwards of thirty volumes upon the most profound themes which can engage the human mind.

"If the reader be a student of nervous diseases, let me ask him a question. Suppose a brain has become weakened by over study, so that positive organic disease has been superinduced in the form of persistent hallucination, is that disease likely to remain at a stand-still if the conditions under which it developed are continued? Now it is a fact that in Swedenborg's case these conditions did continue. He never paused. He never rested. He was not even regular in his hours of sleep, nor in his time for meals. If insanity had developed in the green tree, what would it have done in the dry? If it had taken on even a mild form of hallucination at fifty or fifty-five, what would have been its form in the feebleness of extreme age? Would the mind have been clear to the last? Indeed, is it likely that such a disease would have permitted him to reach extreme age? We know something of what are termed hallucinations, where people imagine they see and hear what they do not see and hear. But have you ever heard of a case where such a disease, if not cured by rest and change of habits, or else mitigated by an easy-going life, failed to develop, and generally with rapidity, into positive insanity? Now, instead of this, we do not find the signs of wandering or incoherency, but, on the contrary, greater clearness and simplicity as the years roll on." (p. 500-501.)

Continuing, Mr. Goddard quotes from one of the leading authorities on hallucinations—Brierre de Boismont—the following characteristics of those subject to this complaint: "Alternately unsteady, strange, eccentric, gloomy, misanthropical, apathetic, frivolous, incapable of carrying out the least project, . . . they have vainly endeavored, by acts and words really rational, to escape the watchful eye of the investigator." These attributes are the precise opposite of the steady, cheerful, kind, affable, industrious Swedenborg, who carried out, when over seventy years old, projects for which most men would need a lifetime. And in the midst of writing the most profound theological and philosophical treatises that the world has ever seen, he found time to contribute high-class memorials, the best of their kind, on matters of state to enrich the legislative activities of the Swedish Parliament, which were gratefully received and honored by his peers.

The story is told of a Swedish clergyman who, being violently opposed to Swedenborg's teachings, denounced him as a lunatic, and who one day became himself a maniac upon standing up in the pulpit to preach, as if to testify to his own unreliability and to the falsity of his accusation. Is there not a Divine justice by which wanton misrepresentations return at length to plague their originators?

"The spiritual world is the causal world—the world of permanent realities; the things we behold in the world of nature, are but transitory phenomena—effects developed to our sensuous perceptions under conditions of time and space. Man, even while in nature, is a citizen of the spirit-world, and is living, though unconsciously, in its midst. As his corporeal structure is sustained by elements from the material world, so his spiritual being is sustained by elements from the spiritual world. They may be drawn from its upper, or its lower spheres; as are his aspirations, so will be his inspirations; but he can not, if he would, detach himself from *rapport* with its living though invisible realities. Every great spiritual movement in the natural world is impelled onward by the tides and atmospheres of the spirit-world." (Brevior, *Op. cit.*, p. 84.)

This is entirely in agreement with the teachings of Swedenborg, of whom Mr. Brevior says: "Perhaps the greatest Christian seer and revealer of spiritual things since the days of the Apostles, has been Emanuel Swedenborg, truly a man upon whose like we shall not soon look again; eminent in many ways, possessing a completeness of mind and a rounded symmetry of character which it would be difficult to parallel. It is common (alas! that it should be so) to regard ignorance and fanaticism as the natural concomitants of religious earnestness; and especially so, if associated with professions of deeper spiritual experiences, and with a relation to the eternal world of a more immediate and intimate kind than men of ordinary minds are conscious of in their own personal history; or than is familiar to the society in which they move. To those who think thus, I would especially recommend the study of Swedenborg—not his books only, but himself; they will find him an enigma which upon their principles it will be hard to solve." (*Op. cit.*, p. 181.)

If Swedenborg is to be considered an example of "clairvoyance," it will be necessary to define that term, at least in his case, as an opening of *all* of the spiritual senses to the realities of the spiritual realm, which being the world of causes, even natural things become more completely explained and known than is possible through ordinary one-sided experience. Clairvoyant impressions are universal rather than individualistic. This is why they are received by the central sympathetic nerve-system, rather than through the organs of sense.

We are not to conclude that clairvoyant openings are in themselves evidences of Divine inspiration. No doubt this is why Swedenborg did not adduce them in any such way. The experiences are liable to be misunderstood even by their percipients, and yet more by those who are simply attracted by a love of the marvelous. Swedenborg tells us that Martin Luther thought that he was tempted by the Devil whom he saw with open spiritual vision and withstood; but that the spiritual presence was in reality an angel who endeavored (but alas! in vain) to dissuade him from incorporating into his tenets the dreadful false doctrine of salvation by faith alone. (See D. P., n. 258.) To this should be added that Swedenborg assures us from his experience, that there is no supreme personal "Devil," but only evil spirits, who have once been men and whose power is limited to transient rebellion against the laws of God.

In comparing Swedenborg with other "prophetic souls," I think we must recognize that, while no one else has ever been so fully intromitted into the supernatural and its recognition, as he himself declares, still there have been others who have been raised up to perform lesser uses of an analogous sort.

All men, whether they believe in the heavenly origin of her "Voices" or not, are compelled to admit that the Maid of Orleans was pure, unselfish, noble and forgiving; but that the message was no testimonial to the goodness and perfection of the church to which she belonged is shown by that church's becoming accessory to the martyrdom of the Maid,—one of the blackest blots on the pages of the long history of ecclesiastical iniquity. Shall *we* not say that the manifestation was from heaven? "Do men gather figs of thistles?" Let it be well noted that the "Voices" of Jeanne d'Arc were heard in full wakefulness, as were also the

Divine messages of the Holy Word to the Prophets. This Swedenborg tells us. All of the revelations through him were also given in full wakefulness, but by a perception illuminated by an inner light, while he read the Word—an *illumination,* not a dictation, and thus a Divine communication of instruction, while perfect freedom was retained.

The distinction between the mode in which genuine Divine revelation has always been given, with the faculties of the recipient quickened to their most exalted and vivid manifestation, and those spurious scriptures, spoken or written by obsessed individuals in a state of trance without their own knowledge, is complete and significant. "For every one that doeth evil hateth the light, lest his works should be reproved. But he that doeth the truth cometh to the light, that his works may be made manifest, that they have been wrought in God." (John, iii, 20, 21.)

Swedenborg tells us that " 'the oracle of the temple' [of Solomon] signifies the Inmost Heaven, where there is celestial good; therefore all the things that were in it signified celestial good; the ark that was there, and for the sake of which the oracle was constructed, signifies the Inmost Heaven where the Lord is." (A. C., n. 10261.)

All of the ancient temples had their adyta or holy places, their veiled sanctuaries which none but the consecrated might enter. Modern spiritism has duplicated these things and has its veiled cabinets in which the medium sits and from which responses are given, precisely as of old, and for a like reason, namely, because the veiled sanctuary corresponds to the Inmost Heaven, though it may be seriously doubted whether those who superintend these paraphernalia are "angels." Good reasons could be adduced for supposing that the controlling spirits are apt to be demons who misuse correspondences and turn them into an evil "magic" in order to defraud and profane holy things, if not always, at least in a majority of cases. But these things have been examined more critically in another part of this work. Here I will only adduce experiences which may be of use to confirm Swedenborg's statements of the reality of spirit intercourse and of the power of mind over matter.

The learned Babinet of the Institute of France pronounced the phenomena of spiritism "impossible, because they contradict the law of gravitation," as did also Michael Faraday;—in respect to which Dr. Bronson says: "When I throw a stone into the air, my force, in some sense, overcomes that of gravitation. How does M. Babinet know that there are not invisible powers who can take a man and hold him up with his feet to the ceiling, or a table, as easily as I can a little child? . . . That it is contrary to the law of gravitation, proves not that it is impossible, but that it is possible only preturnaturally. It would be a real relief to find a distinguished academician who had learned practically the elements of logic." As Brevior says: "The more completely you prove that the phenomena in question are not due to, and are impossible by any physical agency, the more completely do you establish their necessary spiritual causation." And he quotes approvingly Lord Bacon's words: "We have set it down as a law to ourselves, to examine things to the bottom, and not to receive upon credit, or to reject upon improbabilities, until there hath passed a due examination."

However, while granting the direction of the spiritistic phenomena by an unseen intelligence from the spiritual world, it is not necessary to suppose that there has been a new *creation* of energy. There are sources of energy in the natural world which have never been tapped by us, and which conceivably can be more readily reached and manipulated from the point of entrance of the energy through the spiritual gateway, than they can by us.

"The Spiritualism of today has fallen chiefly among those who were outside of all churches and religious organizations. Professing Christians as a rule would not hear of Spiritualism, they did not want to know more about the Spirit-world. Herein seems to me its Providential mission, and how sad, yet how natural, that those who call themselves the religious classes should be its bitterest opponents. They seem to think it even a sin to inquire further, they had light enough already; perhaps, a little more would show the dust and cobwebs in their spiritual habitations, and, from very shame, they might be put to some trouble to sweep and garnish them afresh; so, they concluded to put up their shutters, and if Spiritualism met them in the streets, to frown upon it as not being either respectable or needed, and to pass by on the other side."

This searching observation by Brevior (*Op. cit.*, p. 346) does, indeed, partly explain the fact that the devotees of the spirit-séances have been largely not only un-Christian, but anti-Christian. The religious forces which might have guided the movement and warned against fallacies and dangers, have abandoned it to its own devices. Truth to say, the scientists have equally "put up their shutters;" but now that a free discussion of the facts begins to be admitted as both reasonable and desirable, we may hope for a better disposition toward a candid, unbiased examination of the evidence. Whenever this is given, the world will turn with gratitude to the stores of genuine information which have been provided in the unrivaled experience of Swedenborg. Here will be found the needed tests whereby we may separate the good from the bad.

"Modern Spiritualism," says Harris, "may be defined, as a series of actions on and in the human spirit and body, and on the objects of the natural world, produced by the more abundant descent of the Divine Spirit into Christendom and the world, for the purpose of unfolding the more interior and spiritual, as well as natural, human faculties, into higher states of force, perception, and utility. It may be defined in its counter movement, as the results produced in man and on nature, by the opposite efforts of infernal Spirits, to take advantage of new openings, to invert to evils, and to destroy the faith. To those who are most thoroughly conversant with the results of modern Spiritual Manifestations there is no room left for doubt, that the multitudinous inhabitants of the Demon World are engaged in a universal movement for the conquest of the human soul."

This definition by the Rev. Thomas Lake Harris, coming from one who was himself a medium, is sufficiently notable as a declaration and a warning, that there is both a good and an evil side to communications from the unseen world. Mr. Harris himself, when acting as a medium, has given many poetical and spiritually elevated communications, full of genuine symbolism, power and beauty. And he has also put forth writings which, when examined in the calm light of reason, on their merits, are seen to be fantastic. The effort to ensnare and to dominate is very thinly veiled in a large part of the spiritistic literature. But often a hidden and malevolent message is concealed under a fair exterior. The message should never be accepted on its face value without a most searching analysis. Some of these persuasive writings are so subtle that only the Divine teaching, given through Swedenborg, is competent to detect their fallacies.

If by "Spiritualism" Mrs. Courtland means what the French have named "spiritism," or the anti-Christian propaganda which comes from obsessing discarnate spirits whose only motive is to gain dominion over the souls of men on earth, we can sympathize with her wish that she be not confounded with the dupes of such spirits. But when the name of Spiritualist is taken by such an individual as Daniel Dunglas Home, it takes on a new meaning. It is interesting to recall that in his younger days, at the solicitation of Professor Bush, coupled with the offer of a residence for study with him, Mr. Home had decided to prepare for the New-Church ministry and to devote himself to spreading the teachings of Swedenborg, but was deterred by seeing, when fully awake, the spirit of his mother who said: "My son, you must not accept this kind offer, as your mission is a more extended one than public preaching." How fully this prediction was fulfilled may be seen from his wife's memoir: *D. D. Home, His Life and Mission* (London: Trübner and Co., 1888.) Home's "mission" was not to instruct nor to proselyte, but to demonstrate the power of spirit over matter, to convince such men as the distinguished chemist, Crookes, and the astronomer, the Earl of Crawford and Balcarras, to restore a belief in immortal life to thousands of "doubting Thomases" in all parts of Europe, to touch with healing hands, to suffer calumniation and yet maintain through it all the spirit of forgiveness. If "by their fruits ye shall know them," the Spiritualism of Home accomplished as much as any gift of teaching would have done. Others have had some of these gifts and have misused them to obtain wealth and power for themselves. Apparently, Home sought only to demonstrate the reality of the spirit world. Nevertheless, I am creditably informed that he was by no means the angel he is sometimes represented to have been; that he was not always truthful and this sometimes laid him open to control by deceitful spirits, for we attract to ourselves spirits of a like sort, both good and evil. This phase of his character has been given notoriety in Browning's "Mr. Sludge, 'The Medium,' " but with more evidence of a violent prejudice than of perspicacity. It should be noted that Mrs. Browning who witnessed the same phenomena with her husband, did not share his views, but believed in Home's essential goodness and in his miraculous power. Sir William Crookes conducted an elaborate series of scientific experiments with Home under circumstances in which any deception would have been impossible without detection. Mr. Home did not attempt to explain the *modus operandi* of the wonders produced through him by spirit agency,—such as his levitation (witnessed on more than a hundred occasions and by many people), his being floated in the air about the room, or out at one open window (at a height of some seventy feet above the ground) and then in at another (witnessed by the Earl of Crawford and Balcarras and two others who described the occurrence in point over their signatures); the lifting of enormous weights *without the touch of a human hand,* and their continued suspension in air (the lifting of lesser weights was automatically recorded on the apparatus of Crookes); the playing of unseen hands (sometimes of visible hands) upon musical intruments which floated in the air above the heads of the audience without visible agency in private apartments where there could be no concealed machinery (all plainly seen in full light); spirit voices audible to all the company; materialization of soft, *warm* hands (ending at the wrist), sometimes with peculiarities recognized as identical with those which once belonged to deceased relatives of the beholders, hands which caressed, or which allowed themselves to be grasped and then melted away; the handling of live coals with bare hands, bathing of the medium's face in fire as if it had been water (recalling the miracle of Shadrach, Meshach, and Abed-nego in the fiery furnace); and many other abnormal phenomena in the greatest variety.

We should not wish to say that Home was *never* obsessed by evil spirits, because he was only human; but apparently these manifestations, like those of the Apostolic Age, were given to redeem the waning belief in immortal life in a materialistic age and to save this belief from utter extinction in multitudes of people.

Some there were who valued Home more for his friendship than for his fame. His feats were witnessed by a few New-Church people, such as Garth Wilkinson and his daughter, and the sculptor, Hiram Powers. But those who *see* the *truth* as given by Swedenborg, do not need such testimonials of the reality of the spiritual world, and are satisfied with the Saviour's words: "Blessed are they that have *not* seen [with the eyes of flesh] and yet have believed." (John, XX, 29.)

As a young man, while in Rome, Mr. Home was induced to join the Roman Catholic church, which rewards gifts like his with canonization. But he never became a dutiful son of the Church, and having refused to become a monk and devote his talents to the establishment of ecclesiastical miracles, he was subsequently (on a return to the City of Rome many years after) expelled by a Papal decree as a "sorcerer."

Not very many of the purported spirit messages spoken through Home while he was in the trance state, have been recorded and preserved, nor have we any use for such messages, even if from a supernatural source. Testimony is still extant that, when the spirits refused to perform, Home was not above supplementing the "communications" by barefaced lies. It is the extraordinary phenomena witnessed in his presence with every possibility of fraud eliminated, that are of interest. His sayings may be dismissed once and for all as unimportant and open to question. As far as can now be ascertained, none of these sayings are out of harmony with the teachings of Swedenborg. Perhaps this may have come from the remains of New-Church truth from his early years. The spiritistic medium asks for dark chambers in which to display his magic. Home's miracles were performed in the light. He took no credit to himself. When, by his touch, he restored hearing to a little deaf boy, or brought relief from pain to sufferers, we can not, like the Jews of old, say: "He casteth out devils by Beelzebub." When, asking only for absolute faith in the heavenly powers, he was able to transfer his own immunity against the destructive operation of fire to his friends and to place live coals in *their* hands from his own without harm, thereby recalling the words of Jesus: "Behold, I have given you authority to tread upon serpents and scorpions and over all the power of the enemy; and nothing shall in anywise hurt you." (Luke, X, 19), he was but exhibiting corporeally the power over the enemy which corresponds to the strength from a life which, barring a few lapses, seems to have been blameless. These things, in a representative way, confirm Swedenborg's statements in regard to the great power of the angels (See *Heaven and Hell,* n. 229.) Swedenborg was sometimes subject to the assaults of the infernals, as when he suffered grievous toothache from the approach of hypocritical spirits (A. C., n. 5720); but he was relieved through prayer to the Lord and the resulting removal of the spirits by the interposition of the heavenly powers. Swedenborg was assaulted by the infernals, but was defended and protected by the Lord. No one has ever accused him of telling an untruth. Home's case, like the entire history of dealing with the spirit world, *not* under the Lord's leadings, is mixed good and evil.

May we not say that clairvoyance and its associated powers are illustrations of that spiritual law which, in the spiritual world, *takes the place of the law of gravitation* in the physical universe, namely: Like attracts like? If so, a soul which is pure enough from evil to aspire to and seek the Lord, may reflect scattered rays proceeding from the Divine Omniscience, and may receive the angelic protection which can only be given to those who have faith in the Lord.

These things also confirm the truth of some of the things related in the letter of the Word (that the Lord walked upon the waters of Galilee, overcoming gravitation, that He vanished from the sight of a mob, bent on His destruction, etc. and demonstrate that miracles still exist; but they do not in themselves confer either genuine spiritual perception or regeneration, nor can they be compared with the glory of the inner truths of the Sacred Scriptures which are "spirit and life," and which Swedenborg was commissioned to give us.* Nicodemus acknowledged the miraculous cures which the Lord performed as "signs," yet he found it hard to accept the need of a new birth from above.

Neither should we seek to know the future, except as God shows it to us. Occasionally, Swedenborg says that he is not permitted to say more, implying that there are some knowledges which are liable to be profaned and therefore may not be allowed to be generally known, even as we keep some knowledges from the immature.

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* See Swedenborg's "Coronis," LI. Those who have seen interior spiritual truth would be giving up the substance for the shadow, to return into external things which only those in gentile states need.

Philo said: "As long as reason, the light of our mind, still shines and hovers around, pouring, as it were, a noontide light into the whole soul, we being masters of ourselves are not possessed by extraneous influence; but when this light approaches to setting, then, as is natural, a trance, which proceeds from inspiration, takes violent hold of us and madness seizes upon us. For when the Divine light shines then human light sets, and when the Divine light sets the other arises and shines, and this very frequently happens to the lives of the prophets. For the mind that is in us is removed from its place at the arrival of the Divine Spirit, but is again restored to its previous habitation when the spirit departs, for it is contrary to holy law that what is mortal should dwell with what is immortal." Evidently, the ideas of this ancient philosopher were not clear as to the nature of inspiration. He thought it akin to madness.

Inspiration is the opening of an inner door in the mind, but distinctions must be made. Divine inspiration and demoniacal possession are as far apart as the antipodes. One is freedom, the other slavery. Socrates and Swedenborg were God-possessed, but not "mad." They did not speak in trances. We are to listen to the inspired teacher and receive his teaching gladly, when he gives evidence of being God-possessed; but things "inspired" by spirits must be taken with great caution. Still, a blind rejection of all that bears the stamp of the supernatural will rule out the prophetic voices and the messages of the angels, which are the very essence of the Sacred Scriptures, and will value only the mediocre and the inane. For genius has ever been the recipient of the Divine fire and "the testimony of Jesus is the spirit of prophecy." (Rev., XIX, 10.)

I think we must conclude that there are certain individuals of the prophetic or mediumistic constitution, who are able to separate the limbus from the flesh temporarily, and who can sometimes project the limbus to considerable distances, or surround the body with a sphere of the limbus-emanation and thereby obtain immunity from danger, as from fire, etc., or exert various efforts at a distance by its means. How else can we explain the obtaining of evidence of the Stockholm fire by Swedenborg?

Scientifically considered ,no distinction can be made between the "sons of the prophets" of ancient Israel and our modern mediums. Nor is there any special moral distinction. Even though the gift of prophecy be genuine, it is not proof against temptation, nor immune from the punishment which follows a violation of the Divine decrees. Balaam the son of Beor, the man whose spiritual eyes were opened, hearing the words of God and seeing the vision of the Almighty (Numbers, XXIV), surely yielded to temptation and was rebuked. The warning of Isaiah XXX, 10-11, shows that prophecy has always been liable to perversion. Without the continual provision and guidance of the Lord, the Word of God could never have been written. Even Moses—though a man of God—was guilty in this respect (See Numbers, XX). The function of a thaumaturgist is one of special danger, because it is liable to bring contact with the spirits of falsity. Swedenborg's office of revelator demanded supreme truthfulness, and he was therefore warned against this insidious danger, of which abundant confirmation is at hand, and was preserved from the danger by not attempting to perform miracles.

Swedenborg, though endowed with the prophetic gift, refused to exercise it after the manner of the prophets of srael to produce prodigies, except to the extent that his ntromission into the spiritual world was really more wonderful than any physical marvel would have been. He insisted that in the present age we should be led by reason and not by miracles. But if the man of science still demands scientific evidence of the intercourse between the spiritual and the natural worlds and of the reality of that connecting link between the two—the limbus—such evidence is forthcoming and can not be gainsaid.

Crookes found that phantoms could be produced and while they endured, the body of the medium lost weight, sometimes to the extent of half of its weight. This is a most extraordinary fact for which, as yet, no explanation is in sight, unless we are to suppose that the extended limbus (itself elastic and amenable to distortion, while preserving its ability to convey or exert force) is able to effect a pressure on the floor sufficiently to give this partial "levitation." If the maximum force observed by Crookes were to be doubled, the body might, indeed, rise up an float away

The ability to partially draw out the limbus from the gross body, with a hovering over the latter for a considerable time during great agony, *accompanied by temporary entire relief from pain,* was granted to a friend of mine Swedenborg states that the simple fiber, formed out of th universal atmosphere of the starry heavens, and whic seems to be the essential component of the extruded limbus though a little gross matter from the body may adhere an has been detected by chemical analysis, can not be hurt. "Thi form, because it is above other forms, can not be touche at all by them, still less can it be hurt; it is most secur from all injury." ("*The Soul or Rational Psychology,* n. 4.) Like the atoms, which are also formed out of th aura, the limbus shares with them a permanence and freedom from decay which are extraordinary.

Science has hitherto been powerless to alter the mass an gravitational attraction of a material body to the slightest extent. If spirits are able to accomplish this feat, it must be because the rhythmical pulsations which produce gravitation are in the universal aura, which is the next discrete degree below the spiritual atmosphere in which spirits dwell. But in any case a *medium*, or intermediate living form connecting spirit with matter, is needed. Let us hear what Swedenborg has to say of phantoms:

"To the end that these things might be demonstrated to me to the life, there came to me a spirit who could become the subject of all sorts of persuasions, for such spirits are very numerous. In fact, they know no otherwise than that they are the person whose conception they adopt. They can thus personate others to the life. Wherefore in order that no one to whom such spirits address themselves may be led into error, it is necessary to know once for all that such phenomena are extant and are well known in the sphere of spirits. The spirit in question was examined in several ways ,in order that it might be known which of my acquaintances in the life of the body he had been. At length he turned out to be an individual who was living six months ago, though whether he be yet dead I do not know. One would have thought that it was he, for this spirit could clothe himself with the [seeming] personality of this man very exactly." The surrounding spirits, who could know from Swedenborg's memory what this individual was like, were of the opinion that it was indeed he; but Swedenborg says: "As for me, I hold to the following explanation, to wit, that it might possibly have been he, but that nevertheless I am not convinced of this, because such imaginary personations are possible." (*Spiritual Diary*, n. 890, in the year 1748, Feb. 20.)

Thus Swedenborg, while assuring us of the actuality of the appearance, warns us against accepting it as necessaril genuine. Phantasms of people who are still living hav been obtained by Psychical Research, confirming Sweden borg's scientific caution. This shows how easy it may b to get a false impersonation in a spirit *séance*, and sugges that possibly most of the materalizations of supposed d ceased relations and friends may be frauds, not in the sens that they are not genuine spiritistic manifestations, b because the mischievous spirits who do these things lo to deceive.

Whatever the mode by which these extraordinary ph nomena are effected, we may be certain that they be witness to the power of soul over matter. They reveal power back of nature, which is spiritual and which natu must obey.

We can not admit the suggestion of Dr. Geley th conscious substance and its physiological manifestation whether normal or supra-normal, have been evolved a "surge up from the depths of a mysterious and impen trable *unconsciousness*." The flow is in the opposite dire tion. *Life*, divinely and infinitely conscious, creates receptacles and then fills them. Dr. Geley is on the ver of a true conception when he speaks of a directing dyna ism which "itself obeys a directing *idea*;" but this is inco patible with his "unconscious" source. Here he is followi the same disorderly and misleading suggestions which spir of falsity are all the time infusing.

Naturalism, whether in this world or the next (for p ting off the body does not remove the desire of the natu man to rule over or to abolish the higher things of t spiritual life to which the lower motives are inimical), perpetaully introducing the subversive falsity that the lo has produced the higher.

"Learning is such that it desires nothing more than to push itself into celestial things and explore them [from its own priciples]; but this is contrary to order, for thus it violates the celestial things. Order itself is that the celestial by means of the spiritual should enter into the rational, and so into the faculty of learning, and adapt this to itself; and unless this order is observed, there will be not wisdom." (*Heavenly Arcana,* n. 1475.)

This, however, does not forbid us to test whatever psychical phenomena appear on the plane of nature, by suitable experiments after the scientific manner.

Professor Crookes, improving the crude apparatus of Dr. Hare constructed a still more sensitive instrument consisting of a delicate lever whose motions could be recorded on a slip of smoked glass drawn along by clock-work. The apparatus was so solidly mounted that moderate shaking of the table produced no deviation of the trace from a straight line; when, however, the hand of a medium rested even lightly upon the table, fluctuations of the trace were observed; and with the powerful medium, Mr. Home, no contact whatever was necessary, but large movements were produced when the medium's hand was held a foot or so above the apparatus.

The experiments of Crookes were witnessed on several occasions and vouched for by some of the most eminent men of science in England. Perhaps the most noteworthy were those which he conducted in his own house under strictly test conditions with the trance-medium, Miss Florence Cook (a girl of excellent character in the flush of youth, whose parents consented to the tests), under the control of a spirit who called herself Katie King.

It has been claimed that under the influence of disembodied spirits acting upon the organic emanation from the

body of the medium, it is possible not merely to transpo
objects from one place to another, but to take of the su
stances of nature and *construct* temporary and even pe
manent objects, or "materializations." Professor Crook
was convinced that he had obtained such evidence and mai
tained his position to the end of his long life. The read
is referred to the following work: *Researches in the Ph*
nomena of Spiritualism. By William Crookes, F.R.
Reprinted from The Quarterly Journal of Science. Londo
1874. From this work I quote the following account
a photograph of the materialization of the spirit calli
herself "Katie King."

"One of the most interesting of the pictures is one
which I am standing by the side of Katie; she has her ba
feet upon a particular part of the floor. Afterwards
dressed Miss Cook like Katie, placed her and myself
exactly the same position, and we were photographed
the same cameras, placed exactly as in the other experime
and illuminated by the same light. When these two pictu
are placed over each other, the two photographs of mys
coincide exactly as regards stature, etc., but Katie is h
a head taller than Miss Cook and looks a big woman
comparison with her. In the breadth of her face, in ma
of the pictures, she differs essentially in size from the
dium, and the photographs show several other points of
ference. . . . I have the most absolute certainty that M
Cook and Katie are two separate individuals so far as th
bodies are concerned. Several little marks on Miss Coo
face are absent on Katie's. Miss Cook's hair is so dar
brown as almost to appear black; a lock of Katie's wh
is now before me, and which she allowed me to cut fr
her luxuriant tresses, having first traced it up to the sc
and satisfied myself that it actually grew there, is a

golden auburn. On one evening I timed Katie's pulse. It beat steadily at 75, whilst Miss Cook's pulse a little time after, was going at its usual rate of 90. On applying my ear to Katie's chest. I could hear a heart beating rhythmically inside, and pulsating even more steadily than did Miss Cook's heart when she allowed me to try a similar experiment after the *séance*." (p. 110.)

It is customary for skeptics to deride similar things and to say: "Oh yes, a case of double exposure of a photographic plate." But the plates in question were prepared and developed by Professor Crookes himself, or by a trained assistant. Several things are demonstrated by these carefully devised experiments: (1) That Katie King when she came out of the cabinet was not the medium fraudulently impersonating a pretended spirit. In addition to the points of divergence of the two forms, witnessed by the beholders and made certain by the photographs, Professor Crookes was permitted to enter the cabinet and to *see simultaneously*, the medium, clad in a black velvet dress, unconscious and motionless in a deep trance, and standing by her side the white-robed Katie. (2) The appearance of the woman in white was not produced by hallucination of the beholders, or by the opening of their spiritual eyes, for it could reflect the light of an electric lamp and be photographed. The body was therefore formed out of some sort of material substance. This substance was temporarily under the control of an independent human organism, having a heart, lungs and a mouth capable of carrying on a vivacious conversation, controlled therefore by a brain, and able to produce for itself, apparently out of the atmosphere, at least on a plane of existence barely removed from lifeless matter, what was at any rate a very fair imitation of human hair; and a portion of this material emanation could be cut off and preserved, although subsequently the rest of the forr vanished instantly.

The conclusion seems to be forced upon us that, th limbus of the medium being extruded outside of the gros body, and being itself an organized form, this limbus of th medium can be temporarily infilled by the disembodied spir and more or less perfectly molded to its own shape, and tha by means of the limbus, under spirit-control, it is possible t lay hold on substances in the atmosphere and to weave the into substantial forms which are genuine materialization I make no assertion as to other alleged instances of th phenomenon, but the present example is vouched for by or whose honesty and scientific acumen are beyond doubt.

Perhaps the most astonishing of these occurrences can at the final parting of Katie from her medium. "Stoopi over her, Katie touched her and said: 'Wake up, Florri wake up! I must leave you now.' Miss Cook then woke and *for several minutes she and Katie* (the latter st clothed, we must presume, in the limbus borrowed fro the now awakened medium) *and Professor Crookes sa each other face to face and conversed together.* Tearful Miss Cook implored Katie not to leave her, but was to that her work was ended. Weeping hysterically, Miss Co would have sunk to the floor but for Professor Crook support, and at the same time Katie vanished to be se no more.

SECTION C

The Distinction Between Divine Miracles an Magical Miracles—Let Science Take Notice!

In the previous section we have touched upon some pects of modern Psychical Research in its bearing u Swedenborg's disclosures concerning the spiritual wo and the nature of man. The subject of miracles deserves a more detailed consideration, because it is one into which natural science is being led, somewhat against its will, and it is one where Swedenborg's help is most urgently needed. He has led the way. All will be well if science will follow his leadership and not dismiss the whole subject with a flippant jest, when it should, like Moses, be putting off its shoes before the burning bush.

Before entering upon the special subject of my title I must prepare the way, or establish a groundwork of accepted principles, which can serve as a basis for my thesis. In fact the chief part of the labor consists in this preliminary preparation.

To any one who asserts dogmatically, that miracles are *impossible*, I would answer with Huxley: "That word is not in my dictionary." The word, miracle, means essentially any wonderful thing, and whatever is outside of our little catalog of experiences appears wonderful until by frequent repetition the newness wears off. We accept, then, as a fact of experience, anything for which there is sufficient evidence, and merely affirm that when apparent facts are in seeming contradiction, further enlargement of our experience will clear up the discrepancy. We are obliged to acknowledge the reality of many things which we do not, as yet, understand.

THOSE WHO BECOME MAGICIANS IN THE LIFE AFTER DEATH

A materialistic science which has no faith in the life after death and no belief in Divine Providence is apt to consider a belief in miracles or magic as evidence of gross superstition and prides itself on being above such things. Strange to say, Swedenborg found that in the life after death, such become addicted to magic above others.

"They who have ascribed all things to nature, and also to their own prudence, and who by various arts have raised themselves to honors, and have gained wealth, in the other life study magical arts, which are abuses of Divine order, and in which they perceive the greatest delight of life." (*Heaven and Hell*, n. 488 [3].)

He tells us many things about magic and magicians in the Heavenly Arcana. For instance, in n. 831[2], he tells of certain wicked women:

"Who become Enchantresses or Sorceresses in the other life, some of whom are those called Sirens; and they there lay hold of arts unknown in the world. They are as sponges that imbibe nefarious artifices; and are of such talent that they quickly put them in practice. The arts unknown in this world which they gain in the other are that they can speak as in another place, so that their voice is heard there as from good spirits. They can as it were be with many at the same time, thus persuading others that they are as if present everywhere. They can speak as several at the same time, and in several places at the same time. They can turn aside what flows-in from good spirits, even what flows-in from angelic spirits, and in divers ways pervert it instantly in favor of themselves. They can put on the likeness of another by the ideas of him which they seize and assume. They can inspire any one with an affection for themselves, by insinuating themselves into the very state of another's affection. They can withdraw suddenly out of sight and escape unseen. They can represent before the eyes of spirits a white flame about the head, which is an angelic sign, and this before many. They can in divers ways feign innocence, even by representing infants whom they kiss. They also excite others, whom they hate, to kill them—for they know they can not die—and then divulge it and accuse them of murder."

THE MAGIC OF ANCIENT EGYPT AN ABUSE OF CORRESPONDENCES

Of the ancient Egyptians we are told (*Ibid.*, n. 5223 [2]): "The magicians of that time were acquainted with such things as are of the Spiritual World, which they had learned from the correspondences and representations of the Church; and therefore many of them had communication with Spirits, and thence learned illusory arts, whereby they performed magical miracles; whereas those called 'the *Wise*' did not care for such things; but solved enigmas, and taught the causes of natural things."

These revelations warn us that there is an evil magic and that it is from the hells. That there is also a permissible magic, in which the Arabian magi were versed who came to pay their homage to the infant Jesus at the Savior's birth, will be shown presently; but first let us inquire whether anything is known on the subject from modern instances. No allusion is meant to spurious magic or the tricks of conjurers.

THE NECESSITY OF AN INTERMEDIATE SUBSTANCE BETWEEN SPIRIT AND MATTER

There are many modern examples of magic or what is closely allied to it, which demand explanation. Since many people find it difficult to conceive of such explanation, I will first describe some attempts to establish a rational theory.

In The New-Church Review for January, 1907, is an able article by David Goyder, M.D., on "The Substance Between Spirit and Matter," which, without denying the discreteness of spirit from matter, sets forth the need of an intermediate whenever the two are to be consociated. This connecting link is designated by the noncommittal word "substance," which may mean a form of energ which is capable of acting either spatially or nonspatiall according to need, but which is to be distinguished fro that invariable store of energy permanently invested i nature to which the doctrine of the "Conservation of Energy" applies. It is the "limbus," or immediate coverin of the spirit, about which Swedenborg writes, to be distinguished from the gross body of matter. The spirit itse is a form, an organized spiritual body, into which the continually flows the uncreated life from God.

LIFE AND ENERGY ARE UNCREATED BUT FLOW INTO CREATE RECEPTIVE FORMS

In *True Christian Religion* (nn. 471,472) Swedenbor says: "Who that is able to think from reason elevated abov the sensual things of the body, can not see that life is n creatable? For what is life but the inmost activity of th Love and Wisdom which are in God and are God, which li may also be called living force itself? . . .From the fore going we may perceive and conclude that the followin things are not creatable; that is to say: (1) The infinit is not creatable. (2) Nor love and wisdom. (3) Nor li therefore. (4) Nor light and heat. (5) Nor even activit itself viewed in itself; but that Organs receptive of the are creatable and are created."

This appears to be identical with the physical axiom th perpetual motion can not be created by man. Energy ca neither be created nor destroyed. Matter which is create by light, is such an organ receptive of energy, thermal o otherwise. The matter may be destroyed. The energy ca never be destroyed. Energy from the spiritual world m be temporarily manifested in this world, but unless co joined with matter, it has no permanent residence here. Y life and energy which are uncreated, can flow-in when suitable receptacles are given. Thus we read (*Ibid.*, n. 470):

"What is man's spirit but a receptacle of the life of the mind? The finite things of which it is composed are spiritual substances, which are in the spiritual World, and are also conveyed into our earth and hidden therein. Unless they were there together with material things, no seed could be impregnated from inmosts, and then in a wonderful manner grow up, without any deviation, from the first shoot even to fruit and to new seed; nor could any worms be procreated from the effluvia of the earth and the exhalations of vegetables, with which the atmospheres are impregnated."

That is to say, the life of even the most primitive creature does not consist in the mere reception of effluvia of the earth, but spiritual substances (which are invisble and intangible to the natural senses) must be adjoined in order that life which is uncreate may flow-in. While spirits can not *create* life, they are able by means of spiritual substances, "conveyed to our earth and hidden therein," to control and guide the reception of life. That is the way in which plants which were originally good and useful, have been turned into poisonous plants by the hells. That such poisonous plants can be made of use in the control of disease (also induced from the hells) or used, as Swedenborg says, "to absorb malignities," is an evidence that the Lord is still in control and that evil 's obliged to furnish a remedy for its own misdeeds.

CREATION OF FORMS RECEPTIVE OF LIFE BY SPIRITS, AND PRODUCTION OF TEMPORARY FORMS

Now, just as spirits in the spiritual world, though they can not create life, are permitted to create some of the forms receptive of life and thus determine the direction of life's flow, so it appears that they can create from organic substances already in existence, certain materializations whicl while they may not be complete or permanent, do for time exercise functions determined by their creators. Sinc this is contrary to the usual course of nature, such contro while possible, appears to be disorderly, at least as a rul And in any case an intermediate between the two worlds i required. This is both an intermediate substance and an intermediate being of earth who will do the bidding of the spirit

EXAMINATION OF DR. GOYDER'S SUGGESTION THAT SPIRITUA "SPHERES" ARE ELECTRIC OR OTHERWISE EMANATIONS

Dr. Goyder's article requires emendation in some respect in order to bring it into agreement with facts of science recently discovered. For instance, he surmises that ther may be a similarity between the "emanations" from th radioactive elements and those spiritual "spheres" whicl accompany men according to Swedenborg. Dr. Goyder' thought is that radio-activity and "the wonderfully penetrative power exerted by what are known as the X-ray 'are' phenomena of the imponderable natural substances. But this can no longer be maintained. Radium emanatio is now known to be a gas, composed of atoms having definite atomic weight, subject to the laws of gases an having definite chemical properties. The X-rays are invisible etherial radiations, differing from light only in bein of excessively short wave-lengths to which the eye can no respond. Radiant ether has momentum and therefore mas and is not imponderable.

The cerebro-spinal fluid which Swedenborg and the olde anatomists called the "animal spirit," Dr. Goyder identifie with the limbus which is formed, according to Swedenborg of "the purest substances of nature," which statement, i it refers to the aural essence of matter, may indeed imply an imponderable natural substance. But Dr. Goyder thinks that the nervous system is composed of vessels and says: "Let us ask what is the use of nervous tubes if they hold nothing? or of the membranes which enclose nervous masses and their cells if there is nothing to be enclosed? Do not the heart and blood vessels exist as such, because they have a fluid blood to contain and convey? Therefore comes the question again, what is it that fills the whole nervous system, constitutes the nervous influence which renders sensitive and movable this whole human frame?" And he suggests "that it is one of the higher or imponderable substances of nature." And further on he says: "To my mind it appears to be of the character of electricity or of the nature of ether, because these answer to the powers which are exerted by them through the brain, the sympathetic system and the nerves." But do they answer?

It is now definitely known that the speed with which a nervous impulse is transmitted along a nerve has no relation whatever to the speed of light or of electricity but is immeasurably slower. While the nerves by their office do have an analogy with telegraph wires and while it is true that, as Galvani discovered, the passage of an electric current into the nerves of a frog's leg will cause the muscles to contract, this is not the source of their contraction in the living animal.

Again, Dr. Goyder says: "In this large Cosmos, electricity and ether pervade it as higher, subtle and unorganized fluids, not as material substances like stone, water, or air, which can be handled or weighed, but as substances which elude these guages, and transcend them." But this is no longer to be considered true. The electron, or least particle of electricity, has had its weight determined by indirect but conclusive means. Its mass is quite accurately known. The light-quantum has been guaged. We can no longer differentiate these entities from "stone, water, or air," for these are composed of nothing but electrons.

THE NATURE OF THE INTERMEDIATE SUBSTANCE AS DEFINED BY SWEDENBORG

Moreover, Swedenborg to whom we must continually come back, never said that the limbus was composed of electricity and we should go further back to find that "purest substance of nature" which shall indeed be imponderable and yet full of energy. We shall do better to look for it in the aura which is the very medium of energy, or better still in a medium still further back, an *intermediate* which can be either spirit or matter by turns, thus vibrating between the two. "The Natural of man is external; middle, and internal; the external of the natural communicates with the world, and is called the external sensual; the internal natural is what communicates with the internal man, which is in heaven; the middle natural is that which conjoins the two; for where there is an external and an internal, there must be a conjoining middle." (*Heavenly Arcana,* n. 10236.) Not that nature can enter the heavenly world. The influx is the other way. But the super-space of the spiritual world is conjoined with the space of nature through man. In an early treatise on "The Animal Spirit" Swedenborg says: "The essence which is midway, or mediatory, between soul and body ought to take its nature from both. The soul is spiritual while the body is material; otherwise [that is, without an intermediate] the spiritual could never operate upon the material or *vice versa.*" Here he seems to have had some idea of the limbus as a composite of spirit and matter. But subsequently he shows that by no means can the natural be transmuted into the spiritual. It is the *form of motion* of fluids in the fibers and vessels of the body by which the spiritual activities of the soul are conjoined with physical motions within the body through correspondences.

SWEDENBORG'S SUPPOSITION OF A FOURTH NATURAL ATMOSPHERE

We may note that while Swedenborg speaks ordinarily of *three* atmospheres of nature, he sometimes says "three or four," as if undecided. Evidently he is feeling his way cautiously, and while no man ever had so wide a knowledge of the subject, on account of his life in both worlds simultaneously, yet we must not be too much overawed by him. His magnificent intellect was still finite, still capable of making mistakes. He is our brother, as well as our teacher. Let us see if we can bring to his aid further facts which may be incorporated in his system and help to establish it on a firm basis. Such facts are not wanting. We are approaching a position where, in view of the possibilities, the outlook is exceedingly interesting, not to say exciting. But let us keep our heads. The path of knowledge is still strewn with difficulties and our journey toward an all-inclusive theory is painfully slow. The old adage still holds: "There is no royal road to learning."

SWEDENBORG'S "SIMPLE FIBER" AND THE MEDULLARY OR NERVOUS FIBER. THE LIMBUS

In his anatomical writings Swedenborg describes the medullary fiber and cortical glands of the brain as compounded out of what he calls "the simple fiber." Our anatomists conceive of the brain as composed of a somewhat gelatinous, solid substance, containing cholesterin and other peculiar organic compounds and having an exceedingly complex organic structure. But what is this "simple fiber" We are told that it is beyond the reach of anatomy. It i thus described in the work on *The Fiber,* n. 279:

"Since then the simple fiber is produced inmmediatel from substances of a celestial form, it follows that it is no of a terrestrial nature, but far removed from terrestia forms; having its origin in the purest ether, or in heaven . . . It is that in which is the principle of natural forces energies and motions, and from which all other forces flow . . . Its qualities can not be expressed in words,—qualitie which if they should be expressed, would appear like paradoxes, to wit: That it consists of simple substances, as o so many units or monads, which are void of figure, extension, size, gravity, and levity, and hence are not material and, that they are so many exemplars representative of thei universe or microcosm; that is, that in themselves they contain in potency everything in the universal corporeal system which, after formation, comes under the senses and become apparent. . . . From such forms, natures, or heavens, i raised up and determined the simple fiber from which ar all compound fibers."

Less elaborately, but with fully as powerful a hold o the world of causes, the subject is summed up in *Divin Love and Wisdom,* n. 257:

"Man's natural mind consists of spiritual substances together with natural substances; thought comes from it spiritual substances, not from its natural substances; thes recede when the man dies, while its spiritual substances d not. Consequently, after death, when man becomes a spiri or angel, the same mind remains in a form like that which it had in the world. The natural substances of that Mind which recede, as was said, by death, constitute the cutaneou covering of the spiritual body which spirits and angels have

By means of such covering, which is taken from the natural World, their spiritual bodies maintain existence; for the natural is the outmost containant. Consequently there is no spirit or angel who was not born a man."

The extract from the work on *The Fiber* is explicit in relating the "simple fiber" to the heavenly atmosphere, and this form therefore belongs to the spiritual atmosphere, and not to the limbus, which is from nature. But the second extract is equally explicit in describing a form which is, of necessity, derived from nature in order that the spirit may not vanish after death, or be absorbed in the infinite ocean of being and lose its identity. It is to our mothers that we owe this boon—the possibility of eternal *individual existence*—for they supply to embryonic human form those substances of nature by which we are forever anchored to "Mother Earth." Do not forget that all power is in ultimates and that there is a region where earth and heaven meet which is peculiarly sacred.

Consequently, when Dr. Goyder says of this innermost substantial form of nature:

"If we could see it in its totality, it would stand forth a human form of fire, constituting a fit intermediate to the grosser material structures of the earthly body on the one hand, and the spiritual structure of the soul on the other. This I would call the electric or ethereal man;"—we may accept this "human form of fire" as a poetic version of what the Hindu philosophers have called the "astral body," but not as a strictly scientific statement.

Of the existence of an electric man composed of the great congeries of electrons within the atoms which make up his body and of their motions and energies, there can be no doubt; but this is a wholly different proposition from Dr. Goyder's speculation.

Back of the electrons is the aura out of which the electrons are formed and which is perpetually receiving th energy which in its essence is spirit. Here, we may be confident, is the region where the *intermediate,* which share the modes of existence of the natural and the spiritua worlds, will be found in its beginnings on the natural side This seems to be Swedenborg's view and in stating it can not do better than to quote Dr. Goyder's own presentation of this part of his subject. He says:

"Swedenborg in *The True Christian Religion,* n. 103, say that every man after death casts off the natural and retain the spiritual, together with a certain circumambient accretion (limbus) derived from the purest parts of nature, bu this circumambient accretion is such that it can be admitte into heaven as the external basis of the higher spiritua structures.

"Again in the *Arcana Coelestia,* n. 3993, Swedenbor shows that the spirit of man, when it is loosed from th body, has with it all things of the external man excep bones and flesh.

"Again in *The Spiritual Diary,* n. 2392, the followin occurs:—'Wherefore men doubt and hesitate and are ignorant that spirits in the body or spirits separated fro the body are real substances, and such substances in ma as are joined to the material parts of his body.'

"The existence of an intermediate substance between th natural and spiritual bodies is here explicitly declared. Swedenborg terms it 'a circumambient accretion derived fro the purest parts of nature.' I stated at the commencemen of these remarks that this intermediate link was not le behind with the material elements at the death of the bod but was taken with the spirit into the higher world. Th this is so appears from the first extract cited, since Sw denborg says that with those who are in heaven the spiritual part is uppermost and the circumambient accretion beneath. The terms uppermost and beneath have not reference in this relation so much to position as we in this world, regard position—inmost in the sense of the more vital and animated, outermost in the sense of less vital; so that we might, without violence to the view intended to be conveyed, regard this accretion as forming the basis and contexture of the spiritual body in whatever situation it may be required, whether in the spiritual bones, flesh, blood, vessels, or nerves; and we may regard it, too, as thoroughly organized, since nothing can be retained in connection with the soul which is formless or elemental. Further than this we do not attempt to follow it."

This fairly represents Dr. Goyden's position in the main, but omitting or repudiating his electric speculations.

Whatever view we may take of the nature of this intermediate, the necessity for it is obvious if the spiritual body, which is not governed by the laws of nature and its space, is to be associated with a natural body during life in this world. But Swedenborg goes farther than this and assures us that the angelic heavens could not endure without resting on the natural world as a basis of reaction. Equally the natural world could not be preserved save by an inflowing of vitalizing forces from the spiritual world, which again requires the help of an intermediate. Is not this what he is vaguely conjecturing when he speaks of a *fourth* natural atmosphere beyond the aura? Without this intermediate, the connection between the two worlds could not be maintained. At death "something is taken away with the spiritual body which had previously adjoined it to the material parts." This "something" limits the activities of the spirit and prevents them from being dissipated by indefinite expansion into multitudinous uses which can only be properly performed when each spirit attends to his own special part in the great drama of creation. The individual limbus has been built up by its long training in the activities of life in the natural world. These have taught it to act in a way different from that of any other organism. The organism has become a machine perfectly adapted to the desires of its builder and owner who can say: "I am the Captain of my fate," but not well fitted to be run by another engineer, in fact incapable of being so run unless the will of the owner can first be put to sleep. And this is so because the Lord wills us to be free and provides for all our needs in giving us this freedom.

THE LIMBUS AS A LADDER OR MEANS OF COMMUNICATION BETWEEN HIGHEST THINGS AND LOWEST

The ladder seen by Jacob in his dream (Gen., xxviii, 11-17) signifies an intermediate by which there is communication from the Lord "even to the ultimates of nature." We read:

"By 'the ladder set on the earth, and its head reaching to heaven, and behold the Angels of God ascending and descending upon it,' is signified in sum as it were an ascent from the lowest; and afterwards, when the order is inverted, a descent." (*Heavenly Arcana*, n. 3701.) "Hence it is evident of what quality are those through whom the Divine things of the Lord descend even to the ultimates of nature, and from the ultimates of nature ascend to Him; and represent the Divine communication and consequent conjunction; which, in the supreme sense, is signified by the Angels ascending and descending on the ladder set on the earth, whose head reached to heaven, and above which Jehovah was standing." (*Ibid.*, n. 3702 e.)

The angels "ascending and descending "conjoin heaven with earth, but in a lowest sense the intermediate conjunctive medium performs a similar office. It does not seem to me quite correct to say that the limbus is "admitted into heaven." The limbus has a dual aspect and it is in its superspatial and spiritual mode that it "enters heaven;" but by its outer or earthly aspect, it forms a basis on which heaven can rest.

The limbus, or organ of individuality, prevents the dissipation of the spirit after death and is likened to those membranes which enclose not only the whole body and separate it from every other body, but which bind up each bundle of fibers, or each least part in a glomeration of glandules, whereby the parts are kept consociated together and yet distinct, and the whole body is like a house partitioned into innumerable chambers.

Summarizing the teachings of Swedenborg in respect to life, Dr. Goyder says:

"The outer universe must exist as a basis to the inward, the natural world to the spiritual, or else the very heavens could not stand; and, in relation to the mind, actions must be performed to give basis and fixity to the thoughts and feelings, or these could not be permanent. We, as men, come therefore into the natural world by necessity, to fix our character for the eternal world, and we take with us the result in the nature which the soul thus acquires. Our characters, I repeat, are formed while the soul is adjoined to the body, the soul being literally built up, of course, from within while we are in contact with the external world [and he might have added, in like manner the body is built up on the model of the spiritual body, its least parts being given either a right-handed or a perverse left-handed twist, according as we choose good or evil, even as Pasteur found that the harmless right-handed hemihedral crystals of tartaric acid, when converted into the opposite perverted shape through the interior rearrangement within the molecules became poisonous]; and it is and must be true that, but for our contact with the physical universe, we could not acquire that middle degree, that circumambient accretion, which is the intermediate between the soul and body, because it must be gathered and organized in association, *pari passu*, with the physical structures beneath it. To my mind, therefore, the doctrine of ultimation necessitates the existence of this or some other such intermediate, since without it neither could the natural body live nor act upon the external world outside it, nor the spiritual body find a fit basis or continent upon which to rest and ultimate itself in the eternal world."

THE MATERIALIZATION OF SPIRIT FORMS. VON NOTZING'S EXPERIMENTS

As the spirit, while on earth, can take hold of nature by means of the limbus and can join every part of the spiritual body with a corresponding physical form, guiding the material particles into their places and so clothing itself with matter, so spirits after death can sometimes especially, if aided by organized energy from the body of a medium, clothe themselves temporarily with matter and produce phantoms. But if the effort is at all successful, the form thus produced is a replica of the intruding spirit who can reproduce in perfection only what appertains to himself or to his personal belongings, such as replicas of garments worn, for in the spiritual world garments represent and correspond to the spiritual states of their wearers.

In Baron Schrenck von Notzing's recent work on "Materializations," is an accurate account of experiments performed with the medium, Eva, in which various protrusions of a plastic substance were seen to issue from the body of the medium. These were not seen with the spiritual eyes, for they were visible to all who were present, whether clairvoyant or not, and they could be photographed. These appearances, when the controlling spirits had become somewhat proficient in the art, took the form of portions of the human body. Later on, numerous full-length portrayals of the human form, clothed in appropriate garments, were produced; but in some cases where flash-light photographs were secured by a battery of cameras, placed in front of, beside, and behind the medium, it was found that the form was incomplete. It was, in fact, a hollow mask, intended to be viewed from the front where the audience were, but inchoate, or even obviously hollow, when seen from the rear. These photographs showed the medium (who had previously been divested of all paraphernalia by which such forms could be imitated) and by her side, or sometimes behind her, appears the figure in perfectly characteristic portraiture. On a repetition of the experiment different faces appeared, but sometimes a peculiar face and figure which could be recognized by all present, came on the scene repeatedly and on different evenings. Reproductions of many of these photographs (all taken under test conditions) enable everyone to verify these facts. Precautions against fraud which seem, if anything, overdone and unnecessary, were invariably taken. The experiments were witnessed by several well known men of science and by women who assisted in disrobing the medium and clothing her in black tights which were afterwards sewed up, so that she could have no access to objects concealed about her person, even supposing that some such objects might have escaped the very rigid scrutiny to which she was subjected. The black curtains by which she was partially shielded from the red artificial light in the room, were carefully examined befor and after the séance.

The medium was invariably hypnotized by her frien Mme. Bisson, and put into a hypnotic trance, during which she talked, but not from her own consciousness. Neithe did she appear to act as an agent of the spirits, that is, t convey messages from them, but talked in an irresponsibl way, which caused the Baron to doubt whether spirits ha anything to do with the phenomena; but that is anothe matter and the Baron, as a confirmed sceptic, must be al lowed his own view point, which need not be ours an which, to some, will perhaps be taken as a testimony to th genuineness of the results, however they are to be explained

The medium gave warning of the approach of the seizur and often appealed for aid to her friend, Mme. Bisson in whose house she lived. She was apparently helped an strengthened when Mme. Bisson, or some of those present held her hands. She often moaned with every appearanc of suffering when the seizures came and was terribly paine by the action of the light when the magnesium flash-ligh was set off to get the photographs. However it may b controlled by the spirits, the emanation from the body o the medium appears to be a living substance, exquisitel sensitive to light of short wave-length, but able, like th photographic plate, to stand the action of a moderate re light. This substance, or ectoplasm, appears like a sensitive elastic, organized material which, being entangled in th bodily structure, is pulled out and manipulated by the invisible agents, who clothe themselves with it and thus obtain temporary visibility, but which elastically recedes into th body of the medium when released.

The phantom was generally connected with the body o the medium by a luminous band which issued through her breast or often directly from her mouth, sometimes from her hands or other parts of her body. It was sometimes permitted that the substance should be handled when it was felt as a cool, moist, smooth and elastic substance, like rubber, and sensitive to the touch. A portion of the emanation was cut off and allowed to fall into a dish, when it did not disappear, but lost all semblance of life and exhibited only a small portion of liquid, of peculiar composition, not exactly like any of the fluids of the body. Slight traces of epithelial cells and other debris probably represented foreign material from the surfaces through which the emanation issued. Indeed it is doubtful whether the liquid was a real sample of the material. It may have been caught up and carried along in the rush of the emanation which itself eluded capture.

Other somewhat similar experiments have been made which show a considerable loss of weight of the medium, when seated on the scales of a balance at the time of the appearance of the apparition. The substance appears to be organic, living, capable of lifelike motions, the hands seen can be grasped and return the pressure, but when held, they melt away. These and the gravitational phenomena suggest that here we have matter which can somehow be dematerialized and rematerialized at will. If we could suppose that the organic material enters into the intermediate state of the limbus and temporarily ceases to be matter, oscillating between matter and nonmatter, we could have a little perception as to what is happening. Were it not for some facts to be mentioned, we might suppose that the limbus of a departed spirit retains the power to clothe itself again with matter derived from the atmosphere. But some terrestrial material which is already organized in the body of a medium appears to be necessary as a basis, or at least as a starting point for the emanation, because, as far as we now know, the presence of a living medium of earth is necessary. Where ghosts appear in haunted houses, the percipient may himself be the medium. The emanation is peculiarly sensitive to light. Perhaps this is the reason why ghosts walk by night. When perception is by the opening of the spiritual eyes to see into the spiritual world, it makes no difference whether it is day or night.

Perhaps the most extraordinary of these manifestations of material forms has been that of hair on the heads of the phantoms, of which a lock has been cut off by permission *and remained after the phantom disappeared*. This hair was examined microscopically and was found to be undoubtedly organic, but entirely different from the hair of the medium. This would argue that the hair was a distinct creation by the spirit, acting upon material borrowed from the body of the medium, but only able to govern the operation through the action of the spirit's own limbus and according to the pattern of its own structures. The hair, being the lowest of the bodily structures and possessing the least life, would be naturally chosen for such reproduction.

OBTAINING OF SAMPLES OF "SPIRIT" HAIR, ETC., BY PROFESSOR CROOKES AND OTHERS

Professor Crookes cut a sample from the dress of the spirit materialization who called herself Katie King, and the hole was filled up, whether immediately, or only subsequently, is not stated. The materialization of Katie King, which has occurred through different mediums and at widely separated intervals and places, is far more remarkable than those studied by Von Notzing. She not only appeared to Professor Crookes while the medium was asleep in a profound trance, and permitted him to cut off a lock of her hair and a piece of her garment, but she allowed him to put his arms around her, to feel the beating of her heart and to ascertain that she was apparently as solid and substantial as himself. She talked with him in a rational manner and all this occurred in his own house in rooms which could not have been tampered with or invaded by outsiders without his knowledge, and then the apparition which had remained visible and unaffected by the full blaze of an arc lamp when her photograph was taken by the Professor, simply vanished. If you say that Professor Crookes and Baron von Notzing and those who viewed these wonders with them were deceived, you have to reject all human testimony. You can not deceive the photographic plate, nor explain how the platform scales register the weight of a phantom, the medium at the same time experiencing a corresponding loss of weight. These, or analogous phenomena, have been on record for the last three-quarters of a century in the experiments of Dr. Robert Hare, Professor of Chemistry in the University of Pennsylvania, inventor of the oxyhydrogen blowpipe and of the Hare deflagrator; in those of the distinguished chemist, Sir William Crookes, discoverer of thallium, of the radiant streams of particles in a Crookes' tube which we now know at Cathode rays or streams of negative electrons, inventor of the radiometer, the little instrument which is set spinning in a beam of sunlight by the force of a molecular bombardment, inventor also of the spinthariscope which exhibits flashing points of light, a miniature of the starry heavens, under the impact of helium atoms from radium, a man who had all of the highest qualities of the scientific investigator; the never-to-be-forgotten experiments of the astronomer of the University of Leipzig, Professor Zöllner, should also be mentioned; and for careful scientific precision, with thoughtful planning and analysis, I would especially commend the experiments of W. J. Crawford, D. Sc., Lecturer on Mechanical Engineering in Queen's University of Belfast and the Municipal Technical Institute of Belfast.

ATTEMPTED EXPLANATIONS PUT FORTH BY THE INVESTIGATORS

I accept the testimony of these men of science as to the facts, but not necessarily the explanations which they have attempted. Crookes, indeed, never tried to explain the facts but simply gave his word of honor, as a man and a lover of truth, that the things were so and maintained the same to his dying day. Baron von Notzing, with a singular obtuseness, although the experiences as a whole were only explicable as the direct outcome of the activities of spirits, preferred to suggest that, somehow, the medium, who was not a particularly well educated or talented person, was able to produce these feats "subconsciously," a favorite word now-a-days, which is much used to conceal our ignorance. His assistant, Mme. Bisson, whose husband had died while the experiments were being conducted, instantly recognized his phantom, as did friends to whom its photograph was shown. She also received written communications through her own hand, under spirit control, which convinced her that it was he, himself. But von Notzing can think of nothing but the subconscious memory of the medium, reproducing the image of the man she had known. Eva's apparitions never spoke, but in numberless other cases the phantoms have both spoken and acted in a thoroughly individual way, and have not only spoken, but spoken in languages utterly unknown to the medium. Such hypotheses as von Notzing's are strained to the breaking point by facts like these. Some hitherto unsuspected properties of the material body have become evident, but the one thing which the medium can not do (and it is a singular omission if she herself is the sole source of the phenomena is to produce a form having even a remote resemblance to her own.* Male and female phantoms appear with equal facility and Eva's constant declaration, while in the hypnotic state, is that *she* does not do these things, but is seized by a power not her own.

MATERIALISM HAS NO EXPLANATION, BUT BELIEF IN DIVINE REVELATION BRINGS ILLUMINATION

It is evident from this and many similar cases that miracles bring no genuine belief in spiritual things to the confirmed materialist. But to one who accepts Divine Revelation as one of the essentials of belief, the others being, as Swedenborg teaches, the belief in God and in the life of charity, that is, of kindly service to our fellow men, which includes a belief in eternal life, because whoever lives well, does so in order that the Heavenly Father's will may be done on earth as it is done in heaven,—to such a one, these things are a confirmation of all that is taught us concerning miracles. They do not imply Divine authorization, any more than did the miracles which the magicians of Egypt performed before Pharaoh ("and they also, the magicians of Egypt, did in like manner with their enchantments," Exodus, vii, 11); but they do illustrate the connection between the spiritual and the natural worlds.

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* The spirits of people still in the flesh are sometimes seen by those on earth, usually for a very short time, just a glimpse. I have myself seen such forms and the Psychical Research Society has collected examples; but these are seen with the spiritual eyes. Swedenborg explains that, in such cases, the individual is temporarily awake in the spiritual world. (See Conjugial Love, nn. 326, 327.)

EXAMINATION FROM THE WORD AND THE WRITINGS OF SWEDENBORG. A FIRST CLASS OF SUPERNATURAL EVENTS

Extract from "Invitation to the New Church, n. 60:

"*Concerning Miracles.*. All things which are viewed in nature . . . take place from the influx of the Spiritual World into the natural; and, in themselves, are marvels; which on account of their accustomed aspect and perennial occurrence, are not accounted as miracles. But know that the miracles which are related in the Word were done in like manner by means of influx from that prior World into this posterior one; and that they were done by means of the bringing in of such things as are in the Spiritual World into corresponding things in the natural world; as that the manna [descended] upon the camp of the Sons of Israel every morning, [was] things flowing down from the bread in Heaven, and brought into the receptacles of nature. In like manner the bread and fishes into the baskets of the apostles . . . and also the wine from Heaven into the water in the waterpots at the wedding . . . and that the fig-tree withered, through there being no longer the influx of spiritual aliment for it, which was nourishing it from the root. In like manner in the rest. So that miracles have not been from causes sought out from nature, according to the insanities of certain of the learned at this day. And therefore miracles are of the Divine omnipotence according to the influx of the Spiritual World into the natural, merely with this difference: That the things which come forth actually in the Spiritual World are actually brought into such things in the natural world as correspond. That this is so, and can be done, is of the Divine omnipotence which is meant by 'the finger of God,' from which the Lord produced His own miracles."

"The Lord's doctrine was what (the multitude who were fed) spiritually ate; from which the natural eating folowed; namely, it inflowed from Heaven with them as did the manna with the Sons of Israel . . . for, when the Lord wills, spiritual food . . . is turned into natural food, in like manner as it was turned into manna every morning." (*Apocalypse Explained*, n. 617 [4].)

The teaching here is explicit, that the manna, which represented in the Israelitish Church "the living bread, which came down from heaven," was a Divine materialization of angel's food. In a sense every plant of earth, every animal is first a spiritual form which is then infilled with material particles and rendered permanent. (See D. L. W., n. 344.)

Now let us examine the distinction between Divine miracles and magical miracles.

The Lord Jesus after His Resurrection said to the affrighted disciples, who supposed that they had seen a spirit: "Why are ye troubled? and wherefore do questionings arise in your heart? See my hands and my feet, that it is I myself. Handle me and see; for a spirit hath not flesh and bones, as ye behold me having. And when he had said this, he showed them His hands and His feet." (Luke, xxiv, 38-40.) This is the spiritual signification:

"The Lord disclosed to the disciples that He had . . . made Divine the whole of His Human even to its Natural and Sensuous, which is signified by the hands and feet, and by the flesh and bones, which they saw and felt; by the hands and feet is signified the ultimate of man which is called the Natural, by flesh its good and by bones its truths; for all things in the human body correspond to spiritual things; the flesh to the good of the natural man, and the bones to its truths." (*Apocalypse Explained*, n. 619 [15].)

After the Lord's Glorification of His Human, the influx

into the very atoms of the physical structure of the body
the Lord Jesus was no longer mediate through the spiritu
world, but immediate from the Sun of heaven. The m
terial vanished to sensuous apprehension and left nothi
behind, for nothing was found in the tomb. The physic
body was dematerialized and became a wonderful Divi
"limbus," analogous to the limbus of man, a perpetual inte
mediate between man and God, a sublimation far beyo
our comprehension and too holy for words, but capab
when the need arises, of being let down to the plane of se
suous perception. The nearest approach that we can ma
to a description of the body which was flesh and bones su
as no spirit has, is to say that it was no longer mere matt
but had become Divine Substantial. As it could pass throu
closed doors ("When therefore it was evening, on that da
the first day of the week, and when the doors were sh
where the disciples were, for fear of the Jews, Jesus ca
and stood in the midst, and saith unto them: Peace be un
you," John, xx, 19); and yet at will the Lord could l
down the Divine influx to the plane of nature and ultima
or materialize flesh and bones in accommodation to th
states of belief of the disciples, which did not rise mu
above material things.

When Jehovah assumed the human by the Virgin, th
inmost soul of that little infant was Divine, but its succe
sive coverings from the Angelic Heavens and World
Spirits—the spiritual and natural minds in their series
were only feeble beginnings, as they are in ordinary huma
infants, yet with a difference, for these feeble beginnin
were essentially Divine and uncontaminated by inherit
internal evils, as they would have been had the procreati
been through a human father. Finally, the outermost d
grees—the limbus and the corporeal and sensual—tak

from the mother, *were* contaminated by tendencies to evil, but these were successively removed by resistence to evil in terrible temptation combats, which began even in earliest childhood. All through the earthly life of the Savior, He was continually putting off something of the finite and bringing down something of the Divine Celestial in its place; until at the end He put off all of the infirm humanity —the Son of Mary—and reascended into the Divinity, retaining His now Glorified Humanity. "With the Lord all is Jehovah; not only His Internal and His Interior Man, but also the External and the Body itself and therefore it is He Alone who rose into heaven with the body also." (*Heavenly Arcana,* n. 1729.) Yet these experiences of earth-life, in which the Divine touched the human and glorified it, will never be lost. "As the Father hath life in Himself, so hath He given unto the Son to have life in Himself." They are the precious heritage of humanity throughout the Ages. They have shown us what God is like. "No man hath seen God at any time. The only begotten Son who is in the bosom of the Father, He hath declared Him." Henceforth, we preach not, with Paul, "Jesus and him crucified," but *Jesus and Him Glorified.*

The appearance of the risen Jesus to the disciples was a genuine materialization, but a Divine Substantial with Infinite Power was back of it. He had materialized the wine at the marriage-feast in Cana of Galilee, and the bread and fishes with which multitudes had been fed. Now He materializes Himself!

Jehovah had manifested Himself of old, but it was by filling angels with His spirit and presence. Such were the angels, also called men, who appeared to Abraham by the oaks of Mamre. That they were materializations is evident, not only because they are called "men," but because they accepted the food which Abrahma provided "and they did eat." (Gen., xviii, 8.)

We recall also that at the last appearance of the risen Jesus to His disciples, recorded in Luke (xxiv, 41-43) "He said unto them: Have ye here anything to eat? And they gave Him a piece of a broiled fish. And He took it and ate before them." Hence the body by which He manifested Himself was certainly materialized. Yet on this very occasion, when He had led them out as far as Bethany, "He was parted from them and was carried up into heaven." Surely this was no ordinary body!

The body which passed through closed doors was a spiritual body, for matter can not pass through matter; but the body which the disciples were invited to handle and which was unlike that of a spirit, in that it had flesh and bones was a Divine materialization. Similarly, the two at Emmaus at first supposed the Lord to be an ordinary wayfarer like themselves, but afterwards "their eyes were opened and they knew Him; and he vanished out of their sight" (Luke, xxiv, 31.) The eyes which were "opened" were the spiritual eyes. The vision before the opening was natural

In treating of similar openings of the spiritual eyes Swedenborg says: "All things in the spiritual world . . . are seen by man when he is withdrawn from the bodily sight and the sight of his spirit is opened. This is effected in a moment, when it pleases the Lord that man should see spiritual things. And then he is not aware but that he sees them with the eyes of the body. Thus Angels were seen by Abraham, Lot, Manoah, and the prophets. Thus the Lord also was seen by His disciples after His resurrection; and in like manner, too, have Angels been seen by me." (*Heaven and Hell,* n. 76.)

This passage does not enter into particulars, but the statement that the transition from natural to spiritual vision can be "effected in a moment," so that possibly the individual percipient might not be aware of the change, is well illustrated by the incident at Emmaus. The angels (men) who visited Abraham at Mamre and partook of his food, "went toward Sodon; but Abraham stood yet before Jehovah" (Gen. xviii, 22.) In his conversation with the Angel of Jehovah, Abraham had "in a moment" entered into the state of his interior. The narrative does not discriminate in this respect, but we can interpret for ourselves. When the angel of Jehovah appeared to Manoah and his wife, the offering of food was refused, and "it came to pass, when the flame went up toward heaven from off the altar, that the angel of Jehovah ascended in the flame of the altar" (Judges, xiii, 20.) By this "Manoah knew that he was the angel of Jehovah," or, as he said, "we have seen God;" but except for such things as the context furnishes, the recipients knew not whether they were in the spirit or in the body. The appearances of the Lord to Mary and Peter—may have been spiritual openings, but where the disciples' food was eaten, a distinction must be made.

In *Last Judgment* (n. 24) it is written: "Although it is according to order, that the spiritual should see the natural, it is contrary to order that the natural should see the spiritual." But in *Continuation of the Last Judgment*, n. 36, we read: "The natural man cannot see the spiritual man, and the spiritual man cannot see the natural man," which are discrepant but are cleared up by the following: "Spiritual [beings] see things which are from a spiritual origin, and Natural ones those which are from a natural origin; and therefore man cannot possibly see the things in the spiritual World, unless he is permitted to be in the spirit. . . . Neither can Angels and Spirits see anything whatever in the natural World, if they are not with a man who is permitted to speak with them" (*Heaven and Hell,* n. 582.) And *Arcana,* n. 5427, insists on the necessity of "correspondence and a medium." Also: "It is the sight of the spirit which sees through the eye. The Spirits with me have seen through my eyes the things in the world as well as I do" (*Arcana,* n. 1954.)

We may here recall that, unlike the invitation to the disciples to "handle" Him, His words to Mary on the resurrection morning were: "Touch me not, for I am not yet ascended to the Father" (John xx, 17), as if some last step in the Glorification had not been completed. He had not yet made His humanity Divine Love in all its fulness; Mary, who of all the disciples loved Him most, must have been of celestial genius. The highest angels can best realize the Lord's perfection and, recognizing it as beyond and above anything that is their own, they desire to worship. Such do not question with Thomas and say: "Except I shall see in His hands the print of the nails, and put my finger into the print of the nails, and put my hand into His side, I will not believe" (John, xx ,26.) The celestials have fuller evidence than outward touch can give and do not ask for miracles.

A SECOND CLASS OF SUPERNATURAL EVENTS. OPENING OF THE SPIRITUAL EYES.

Two classes of supernatural events are recorded in the Word. The first class is sufficiently illustrated by what precedes. The second class includes such things as these:

1. "And Elisha prayed, and said: Jehovah, I pray thee, open his eyes that he may see. And Jehovah opened the eyes of the young man; and he saw; and, behold, the moun-

ain was full of horses and chariots of fire round about lisha." (II Kings, vi, 17.)

2. When the angel appeared to the shepherds with the lory of the Lord, "Suddenly there was with the angel a ultitude of the heavenly host, praising God and saying: lory to God in the highest, and on earth peace among men whom He is well pleased." (Luke, ii, 13-14.)

3. John, in Patmos, was "in the spirit on the Lord's day," hen he heard the "great voice as of a trumpet" and saw e Apocalyptic vision.

4. Ezekiel tells us his experience, how it came to pass, as I was among the captives by the river Chebar, that the eavens were opened, and I saw visions of God." (Ezekiel, 1.) And in the fortieth chapter he tells how he was rought from the land of the captivity, "in the visions of od," into the land of Israel and was shown "as it were e frame of a city" and the temple which had been estroyed, but whose counterpart still existed in heaven, ven as the tabernacle was shown to Moses in the mount, efore it was constructed on earth.

In all of these occurrences, it was the spiritual eyes which ere opened, and the things seen were the glorious realities f heaven.

MEDIUMSHIP IN THE EARLY CHRISTIAN CHURCH.

The facts of mediumship are not new. The early Chrisan Church had communication with the spirit world and as exhorted by John to "try the spirits" to see whether ey acknowledged the Lord Jesus Christ. In the Jewish hurch, the denunciations against wizards and witches were irected against an evil magic; but there were also schools f the "Sons of the Prophets," where a permitted interourse with the spiritual world was cultivated, as may be

seen from the things narrated in II Kings, Chap. II. It
well to be forewarned against evil and fantasy, but rej
not the prophets of the Lord!

VITAL DISTINCTION BETWEEN DIFFERENT KINDS OF SPIRIT MANIFESTATIONS.

In the same class with the materializations described
the Word are the materializations produced by spiri
except that these are not made by their own power, t
require aid from the things which God has made. A
often they are not done in an orderly manner, for th
frequently require the obsession of a human medium, t
taking away of freedom and often considerable sufferi
though this seems to have been entirely absent in Ka
King's medium, where the whole transaction seems to ha
had a useful and beneficient purpose and endured only un
this purpose was accomplished. But where, as in Ev
case, there was much pain and even on one occasion terr
when the medium was violently seized and thrown down
a spirit, something of evil seems to have invaded. All
those spiritistic séances, where the materializations serve
useful purpose but merely cater to a morbid curiosi
where, moreover, there can be little doubt that immo
suggestions or doubts and scandals against the Savior
men are insinuated, and wherever the spirits beseech t
participants to allow themselves to be led by them, promisi
wonderful progress, but actually leading to wickedne
falsity and often to final insanity, such miracles, howev
wonderful they may appear, are magical. Hypnotization
where the victims are persuaded that they see things whi
are non-existent, come under this category.

FURTHER ILLUSTRATIONS FROM SWEDENBORG REGARDING EGYPTIAN MAGIC.

Among the things known to Swedenborg even before his illumination, was this: That the Egyptian hieroglyphics conveyed spiritual truths in a concealed or symbolic form. At one time he offered to explain the hieroglyphics to the Academy of Science, but as little interest was then taken in Egyptology, this offer was not accepted. After his admission into the heavenly world, his knowledge was greatly extended and he learned that the ancient Egyptians derived all their wisdom from the study of correspondences;* and after the perversion of the Ancient Church, the study was still continued by the priests, but for the sake of the power which it gave them by its misuse in gaining for themselves secret and malign influences over others by means of an evil magic.

"Magic is nothing else than a perversion of order; especially is it the abuse of correspondences. . . . When a man believes that all things are of blind influx, and that if anything comes forth which is determined it is of his own prudence, he perverts order; for he applies the things of order to himself." (*Heavenly Arcana*, n. 6692[2].) "Perverted scientifics are those which . . . invert order, like the magical things which were in Egypt; for there are very many things according to order which those magicians had abused. . . . These (correspondences and representatives) follow order even when applied by the evil, and when they are applied by them for exercising command over others, and for injuring others, they are perverted, because magical." (*Ibid.*, n 6052.)

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* For a luminous unfolding of the obscured wisdom which was the foundation of Egypt's greatness, see the work: "Isis and Osiris in the Book of Respirations," by J. J. Garth Wilkinson. Published by James Spiers, London, 1899.

A revival of interest in ancient Egypt (Tut-Ankh-Amen etc.) comes at a time when some of the mysteries of magi are also being revived.

"Those who in the body have used cunning, and hav devised many arts to defraud others, and at last from thei success have attributed all things to their own prudence in the other life learn things magical, which are nothing els than the abuse of Divine order, especially of correspondences. . . . For example, the hands, arms, and shoulder correspond to power, and thence a rod; and therefore the form rods for themselves, and also present representativel shoulders, arms, and hands, and thus exercise magica power." (*Ibid.*, n. 7726[2].)

Was the initial production of arms and hands at Baron von Notzing's experiments part of such a magical performance? The employment of hypnotism ,in at least one instance, led to a serious obsession. The obscuring of the judgment of another by hypnotic control is a magical device well known to confidence men and bunco steerers.

A WARNING TO SCIENCE.

Heretofore a barrier to the scientific investigation of spiritistic phenomena has existed in a distinct prejudice among scientific men against things supernatural. Now that this barrier begins to break down, we may anticipate an opening of the flood gates, with consequences which may well call for the outspoken comment and possible remonstrance of those who realize the meaning and trend of the invasion. An alliance between science and spiritism, constituting a return of Egyptian magic, would be a far more serious menace to spiritual life than any of the crude follies of spiritistic séances of the last three-fourths of a century. If this irruption is coming, it is the more necessary that we "try the spirits," that we distinguish between permissible openings of communication with the spiritual world and an evil magic.

SWEDENBORG ON DIVINE MIRACLES AND MAGICAL MIRACLES.

Divinely permitted miracles may be such as alleviate suffering or restore a belief in immortality. Divine miracles respect and provide for human freedom and are performed through the acknowledgement of the Divine Providence of the Lord God, the Savior, Jehovah-Jesus. Magical miracles take away freedom, seek infernal dominion and deny the Lord. Swedenborg tells us:

"If spirits were allowed to use the Exterior Memory, the human race would perish; for every man is ruled by the Lord through spirits and angels; and if Spirits were to inflow into man from the exterior Memory, man would not be able to think from his own memory, but from that of the spirit; thus man . . . would be obsessed; the obsessions of yore were nothing else." (*Ibid.* n. 2477.)

"It is to be known that Divine Miracles differ from magical miracles as heaven from hell. Divine miracles proceed from the Divine Truth, and advance according to order. Effects in ultimates are Miracles when the Lord pleases they should be presented in that form. Hence it is that all Divine miracles represent the states of the Lord's Kingdom in the Heavens, and of the Church on earth. This is the internal form of Divine Miracles. Such is the case with All the Miracles in Egypt, and also with all the rest treated of in the Word. So, also, all the Miracles which the Lord Himself did when He was in the world, signified the coming state of the Church; as, that there were opened the eyes of the blind, the ears of the deaf, and the tongues of the dumb, that the lame walked, the maimed and the lepers were healed, signified that such as are signified by the blind, etc., would receive the Gospel and be spiritually healed; and this by the advent of the Lord into the world. Such are Divine Miracles in their internal form. . . Whereas magical miracles involve nothing whatever; they are done by the evil to acquire power for themselves over others; and in the external form they appear like Divine miracles. The reason that like things appear is that they flow from order; and the order appears alike in the ultimates where miracles are presented." (*Ibid.*, n. 7337.)

It is said that "the order appears alike in ultimates." The inference from this is that, while the principles involved are similar, the evil end in the magical miracle constitutes it a perverson of heavenly order. This may be compared to the administration of opium by a physician to relieve intense pain, which is a work of mercy; but its administration by a murderer is an infernal perversion of a beneficient thing; and thus, when a thing is capable of such perversion, its use has to be regulated by legal restrictions, and, in general, is forbidden. In the same way, hypnotism is one of the "magical arts," sometimes used to produce seeming miracles, which is capable of very great perversions. Because the past has had its "witchcraft delusions," the law should not forget that there may be criminal hypnotists. We must, then, distinguish, as in the case of the uses of opium, between the employment of hypnotic methods by certain physicians in some brain disorders, where the intention, at any rate, is to do good, and their misuse to control the actions of another and take away freedom.

As to materializations, the thing in which science should be interested is the unexpected light which these experiments throw on the properties of matter and energy. Facts which can be investigated by photography and by self-recording apparatus are within the purview of natural science, whatever their ultimate source may be. But to proceed from these, and these alone, to seek to find out the laws of spiritual life, is not permissible. The higher can include the lower, but the lower can never fathom the higher. The case is still more hopeless, if any light is sought from spirit communications. As Dr. Wilkinson says: "The manifesting spirits seem to exhaust their mission in showing themselves. That they have heads, and legs, and arms, is the pith of their revelation; a lesson for materialism to learn. For the rest, they talk like common folks, and give out no more light than the commonality does in general. As well ask your costermonger the constitution of the natural world, when a Newton is wanted; or about the constitution of the spiritual world, when a Swedenborg is required, as converse with spirits about their opinions."

The only conceivable way in which natural science could contribute to an understanding of the laws of spiritual life would be, if it were permitted that societies of wise ones in the spiritual world, where genuine causes reside, should coöperate with societies of natural scientists in this world. Such communications from the spiritual world, however, would not be science, but revelation. Why not accept the revelations already given through Emanuel Swedenborg, a scientist of unequaled preparation for the task and of known probity? The character of disembodied spirits cannot be vouched for. Even when they purport to be the spirits of men whom we respected and honored in this life, the identity can never be absolutely established but remains at best a presumption, while the majority of such asserted manifestations of former denizens of the earth are obviously fictitiou since the puerilities which they annunciate are utterly unworthy of their reputed authors.

NO MORAL QUALITY IN NATURAL FORCES

The forces of nature are neither good nor evil, that i they have no moral quality. Thus, fire corresponds to love but love may be either love of good or love of evil. So i regard to fire; on coming into the house on a cold day an standing in front of the fire, we say: How good that fir feels. We have, at such a time, no other conception of fir than as something beneficient. But when, in a great conflagration, a human being is burned to death, a pang o horror overwhelms us. Have the properties of fire changed Not at all, but we have to make a distinction between th results of its application or misapplication. The end i view, or purpose, is what makes the distinction. A crimina soul will take delight in applying the incendiary's torch, bu the good man will sorrow over the wanton destructio Deeds which, in themselves, appear exactly alike, are distinguished by their underlying motives.

Storms often do vast damage, but they are a necessar part of the circulation of the atmosphere and are as essentia to its purification as the circulation of the blood is to th life of the body.

"Unless there were storms in the atmosphere, to dissipat whatever is heterogeneous, the air could never be mad clear, but would become deadly by pestiferous accumulations." (*Heavenly Arcana*, n. 842^3.)

We have to take exception to Gopaul Chetti's statemen in his work on "Swedenborg and Saiva Siddhanta," wher he says that storms and earthquakes come from the hell But Swedenborg, while recognizing that the hells can som times divert creative influx and produce baleful forms in nature, such as venomous serpents and poisonous plants (See D. L. W., n. 339) does not place storms and earthquakes in that category. Possibly evil spirits take delight in the *destruction* produced by a storm, yet though "the stormy billows are high, their fury is mighty," we may be sure that 'the Lord is above them and almighty." We must insist that the storms of nature are beneficent, in spite of incidental destruction. In the language of the Psalmist, we see the "stormy wind fulfilling His word." Similarly, earthquakes are also beneficent, since, without them, the continents would not have arisen from the deep.

SCIENTIFIC EXPERIMENTS OF DR. CRAWFORD. SOME NEW PROPERTIES OF MATTER.

If communications with the spiritual world are ever allowable (and we have seen that such permissions are sometimes given) we should expect that experiments conducted with the purpose of finding out something in regard to the nature of the forces employed in the physical production of physical effects—experiments which are amenable to precise scientific tests and in which the good faith of all of the parties concerned is guaranteed by the nature of the phenomena, or is made sure by contrivances for automatic registry, which under no circumstances can be moved without warning, unless by some supernatural agency—would fall under this definition of permissible experiments and should be both useful and devoid of any harmful tendency, especially if the experimenters are actuated by a strong desire to elicit nothing but the truth. Such, apparently, are the experiments of Dr. Crawford. The medium, Miss Kathleen Goligher, was a young woman who did not go into hypnotic trances nor conjure up phantoms, but retained her senses perfectly. The sitters formed a homogeneous group anxiou to be of service and willing to go to some trouble to ge exact results. The communicants, or "operators" from th spirit side, as Dr. Crawford prefers to call them, did no take possession of the medium's intellectual faculties, bu produced physical phenomena only. The use of the corre spondential means noted by Swedenborg—rods of power etc.—were employed. Thus a rod of psychic substanc having been projected from the body of the medium com munications from the spirits were effected by means of th physical motions of this rod, involving the tedious process of naming the letters of the alphabet, when the psychic ro would give a rap at the naming of the correct letter. Though more time-consuming than automatic writing, there is less infringement of the medium's freedom, in fact none at all since she was unable to control the raps.

The process was a complex one. The sitters who forme the circle, in addition to the medium, were an essential part of the paraphernalia of the séance. They furnished the needful psychic and permanent loss of weight, accompanied by a sense of loss, or of depletion, which lasted for some hours. The medium also, when weighed before and after the séance, showed a loss of weight, but it was comparatively small and she was not appreciably fatigued, her contribution being the furnishing of psychic substance which was subsequently reabsorbed or reentered into her body.

The following experiment (from p. 186 of "Experiments in Psychical Science") concerns a professional medium, through whom audible voices, coming from various parts of the room, were produced, though no form was seen. Dr. Crawford does not vouch for her, except, that the phenomena which he tested in regard to the loss of weight, etc., were identical with those of the Goligher circle. The medium, a very heavy woman, being weighed before and after the séance, lost only ¼ pound. The sitters in the circle lost respectively: ¼, ½, 1¾, ¼, ½, ¼, pounds. In all the combined weight of the sitters diminished by 3½ pounds, very differently apportioned and compared with which the quarter pound lost by the medium is quite negligible.

An experiment of like duration, tried by this author with a group of friends who sat for a game of cards, showed no change of weight whatever, capable of being registered by the scales employed. Of course a more accurate balance would have shown slight losses of weight through respiration and evaporation from the surfaces of the bodies. But this evidence is conclusive that the losses during the séance are in some way connected with the production of the phenomena. These consist in a guiding of energy already extant in the natural world, but amenable to spirit control.

Though the permanent loss of weight by the medium was small, she nevertheless experienced temporarily, at the moment of the production of some special feat, changes of weight which were quite extraordinary. While she was seated on the scales of the balance, losses of weight of ten, twenty, or even forty or fifty pounds were recorded. These usually lasted for only a few seconds. Since the contour and dimensions of the body did not change, we must suppose that either some emanation from the body was thrown off into the atmosphere, or else a portion of the substance of the body was dematerialized. In all of these operations the psychic energy from the other sitters assisted the transformation, but did not furnish the bulk of the material transformed.

That the separated substance is able to exert considerable force at a point of application far removed from the medium is a fact which does not favor the gaseous-emanation hypothesis. In favor of the hypothesis that there has been a dematerialization of the body is the following: On various occasions photographs have been secured of a medium while being levitated, or suspended in air without visible support, but of course being upheld by some sort of invisible psychic structure. At such times the physical body appears semi-transparent, as if a part of its substance had disappeared temporarily, or had been dematerialized by entering into the fourth dimension of the spiritual world. That this fourth-dimensional state is a characteristic of the spiritual world was asserted by Swedenborg.

The phenomena obtained with Miss Goligher were not so extraordinary as this and they could not be photographed, because, when the magnesium flash-light was substituted for the red light of the room, "Miss Goligher trembled violently for ten minutes or more. Her arms and legs kept jerking spasmodically and her body every now and then moved involuntarily. But in a quarter of an hour she was quite normal again." (Experiments in Psychical Science, p. 153.) The attendant spirits forbade a repetition of the experiment, asserting that it would be very dangerous. The medium, Eva, in von Notzing's experiments, though suffering considerably from the sudden exposure of the flash, was evidently of a less delicate constitution. Besides this, the emanation from her body was mixed with a certain amount of material substance, so that a piece of it was cut off and analyzed chemically. The projections from Eva's body, such as partly formed hands and arms, or human heads, were visible to all of the observers, the shapes being usually feebly luminous, or at any rate visible in the red light of the room, and they reflected the light of the flash as if they were completely solid. There was no difference between the evidences of sight and photography.

But the cantilever structure by which the emanation from he body of Miss Goligher was able to lift a deal table veighing over ten pounds and hold it suspended in air with o human hand touching it, could not be seen. Its existence vas only inferred from a variety of carefully devised nechanical experiments, for which the author's training as mechanical engineer perfectly fitted him. The explanaion at which Dr. Crawford arrived in this way was, however, confined by the spirits, who tried in every way to arry out his wishes. The *modus operandi* seems to be this: There is first formed a column several inches in diameter, rotruding from the body of the medium and presumably f the intermediate substance of Swedenborg's limbus, vith which may be intermingled some matter in the ase of Eva. This column is really a bundle of small tubes long which a fluid is forced, exerting pressure at the xtremity, somewhat after the fashion of a hydraulic press. But the fluid is said by the spirits to be a *spiritual* substance btained from the bodies of the sitters with which the spirit's own spiritual bodies were conjoined, a spiritual substance which infils the physical bodies of the sitters in the circle and from which it can be extracted in greater or less abundance according to the characteristics of the ndividuals.

Swedenborg has taught us that the phenomena of generation require the simultaneous presence of a material fluid and of spiritual substance. Something similar is in evidence here also. This spiritual substance seems to be nergy in a sense. It can be conveyed by metal tubes. We are at the threshold of impressive discoveries as to the very nature of energy and of matter. Bearing in mind that Swedenborg speaks sometimes of a fourth natural atmosphere, intermediate between the three atmospheres of the natural world and the three of the spiritual world, we ma perhaps surmise that the limbus is formed, at least in par of this intermediate atmosphere. But the spiritual bod which is the man himself and not just a covering whic may be put off, is organized *spiritual* substance, formed o the atmospheres of the spiritual world in two degree indestructible and incommunicable to another individua though able to come into conjunction with others throug its love.

SPIRIT "SPHERES" OF VARIOUS ORDERS.

The spirits of the Goligher circle, while seemingly we intentioned and desiring to be helpful, are not profoun philosophers and are not able to go very far in thei attempts at explanation. The following quotation hints a further complications.

"The operators say that there are different sphere within their world. They say that they themselves belon to different spheres, some of them being in the secon some in the third and some in the fourth. One evening when we had a well-known trance medium with us, a entity purported to control who said he was from th seventh sphere. He said he was the spirit director-in chief of the circle and gave a few homely words of advic and encouragement to the medium and sitters." (Crawford *Hints and Observations for those Investigating the Phenomena of Spiritualism,* p. 19-20.) This refers possibl to those distinctions between spirits described somewha vaguely by Swedenborg in the following passage:

"CONCERNING THE INHABITANTS OF ANOTHER WORLD O SOME UNIVERSE IN THE STARRY HEAVENS.

"When exploration was made as to what is their nature inasmuch as it was wholly unknown to me, that ever spirit could be given, who did not stop in the proximate use of objects, but proceeded from this use to the ninth degree of progression. Wherefore the idea is to be apprehended by means of examples; one example was also granted me; to wit, (they asked why I wished to know it, or what was the use of my knowing it; then I immediately said the proximate use, or a certain general (use); but they did not admit this; saying that after that comes the use which in like manner progresses to their ninth. The progression was also given; hence it was granted to know that there was, as it were, a sort of multiplication of uses in themselves, till they came to their qualities, and quantities, and there rested. There was also granted me by communication, a living perception of their nature, that they are of such character. It was further said that in the earths of the universe (some) are given, who progress to the fiftieth use" (*Spiritual Diary*, n. 3272-3.)

THE SPIRITS ENGAGED IN THESE OPERATIONS ARE MAINLY NOVITIATE SPIRITS.

The spirits concerned in these manifestations are apt to be novitiate spirits in the Intermediate World of Spirits. This is evident from what they say of themselves. "The operators emphatically declare that the fact of death does not in the least degree alter a man's character." (*Ibid.*, p. 17.) This is entirely in harmony with Scripture:

"He that is unjust, let him be unjust still, and he that is filthy, let him be filthy still, and he that is just, let him be just still, and he that is holy, let him be holy still." (Rev. xxii, 11.)

Most abundant confirmation is also given by Swedenborg. But the above "emphatic" declaration shows that these spirits are still in their natural or earth-state. They have not yet met their judgment which separates the evil fro the good; but they seem to be well-disposed spirits, D Crawford says: "The entities say that all our exper mental circles are guarded very strictly on their side so tha no undesirables shall be able to get near." (*Ibid.*, p. 38 Apparently in an orderly circle, precautions are taken o the spiritual side, and they should equally be taken by thos on our side.

These things being so, that is, the participants being sti in earth-bound states, we need not expect any great informa tion about the realities of the spiritual life; but here an there we note a bit of confirmation of what Swedenbor tells us from his more perfect experience. Thus "th operators say that their psychic bodies were incapable o being ill or feeling pain, but—and it is an important *but*— they emphatically declare that mental pain can be felt an endured in their world." (*Ibid.*, p. 17.) We have alread noted (p. 842) that Swedenborg tells us that the limbu cannot be harmed. The spiritual body, however, or th organized spirit, is exquisitely sensitive and, if in disorder it must suffer. Another indication that these spirits have no yet passed their judgment is that they are very reticent o all that relates to this process. They are unwilling t say anything about a heaven or a hell. If there be such things, they have not experienced them. They do vaguel hint at certain "dark" spheres which "are most unpleasan and in all respects undesirable." (*Ibid.*, p. 21.) This is jus a little suspicious; but if there is still some evil in thes communicants, they are at present on their good behavio and as long as they do not try to teach us about importan matters, we can tolerate them.

DANGERS OF MAGICAL MIRACLES.

But to return to the topic of magical miracles, where the actors are out-and-out demons, and where they strip off the mask and inveigh against God and the things which make heavenly life, where, though living in a spiritual world, their talk is that of materialists and nature-worshippers,—then, indeed, let science beware, for it is ill prepared to meet the dangers of the situation. More than one such has committed suicide under the incitation of these demons.

Says Swedenborg: "If evil spirits were to perceive that they are with man, and that they are separate Spirits from him; and if they could inflow into the things of his body, they would endeavor by a thousand methods to destroy him, for they hate man with deadly hatred. As they knew that I was a man in the body, they were in the continual endeavor to destroy me, not only as to the body, but especially as to the soul; for to destroy a man or any spirit, is the delight itself of the life of those who are in Hell." (*Heavenly Arcana,* n. 5863.)

Unless, then, the man of science is guarded against the infestations of evil spirits by a firm belief in the protecting care of the Lord, and unless he goes to the holy Word for guidance and to those authorized Writings of the Lord's "servant," Emanuel Swedenborg, for instruction which has been given for the express purpose of opening the interiors of man's spirit and which shall enable him, if he heeds the instruction, to pass unscathed through the dangers of the new experiences into which the world is now coming, avoiding or rejecting the invitations of infesting devils and keeping the soul open to the gentle leading of our attendant angels, he had better steer clear of the whole subject. The members of the Goligher circle were a united family and always began their séances with prayer and the singing of a hymn. The infernals could not approach under such circumstances.

AMOUNT OF "MATTER" WHICH CAN BE EXTRACTED FROM THE LIVING BODY AND TRANSFORMED.

The operators having stated that the psychic rods, with which they worked, were formed of matter abstracted from the body of the medium, Dr. Crawford requested them to take this "matter" which, be it remembered, was wholly invisible, and lay it upon the scale-pan of a balance, giving three raps when this was done. The medium, seated in a chair upon platform scales, was weighed simultaneously. The decrease of her weight closely followed the increase of weight on the other scales. The operators were asked to make a rod "exactly" similar to the rod they use to cause the sledge hammer blows" on the floor, and "to rest the free end of the rod on the floor—not to press, but simply to rest it on the floor." This being done, the medium's weight was found to have diminished by 39 pounds. Being requested to abstract the maximum amount of matter possible and simply lay it on the floor,—"the weight decreased in fluxes, seemingly as though the operators were pulling the matter out against the action of something resembling a spring. After about the 30-lb. mark was passed the pulls on the medium's body were evidently severe, as she became somewhat restless. Sometimes, when the maximum diminution of weight was being approached, there were quick, jerky decreases of weight which could not be maintained and the lost weight flew back." Finally, a loss of 54½ lbs. "(nearly half of the medium's weight) was fairly held for eight or nine seconds."

Dr. Crawford remarks: "The above are a few of the results which are gradually leading us to the conclusion that the psychic rods which produce the phenomena are, for all their invisibility and impalpability, really packed with matter, but matter which has taken on a form unknown to Science."

We seem to have conclusive proof that the matter has passed into that intermediate or *limbal* state described in our opening paragraphs.

EXTRAORDINARY MATERIALIZATION OBTAINED THROUGH THE EDDY BROTHERS AND THROUGH MRS. COMPTON AND RECORDED BY COLONEL OLCUTT.

Colonel Henry S. Olcutt conducted somewhat similar experiments in 1874. Unlike Miss Goligher who never lost consciousness, but also never gave forth any visible emanation, the mediums observed by Col. Olcutt were in deep trance in a dark cabinet, from which materialized spirits of the most varied appearance and in great numbers issued and were visible to all present, talking with them and behaving in every way like normal human beings. It seems misleading to call them "phantoms." Col. Olcutt chooses for the title of his book: "People from the Other World." The Eddy brothers, through whose mediumship, these forms were produced, had very little education, yet people of various European nationalities, speaking diverse tongues, came forth; and such bizarre performers appeared as a tall Asiatic warrior, armed to the teeth and singing a wild song of his people (understood by only one in the audience); a ferocious looking, half-naked, black "magician" from central Africa; men, women and children, some of them recognized by relatives in the audience as their own loved ones gone before. An Indian girl brought her pet flying squirrel, causing consternation in an old lady in the audience, who had survived the black magician, but scream and climbed upon her chair in mortal terror at the harmle pet. These forms were seen by everyone, but a clai voyant who attended one of the sessions, in addition these, saw many other spirits, which were invisible to t others, by means of her opened spiritual vision.

The Indian spirit, "Honto," owner of the flying squirr was a frequent visitor at the séances of the medium, M William H. Eddy, of Chittenden, Vt. Four successi weighings of Honto gave: 88, 58, 58, and 65 lbs, t medium weighing 179 lbs. With another medium, M Compton, weighing 121 lbs., a materialized spirit, calli herself "Katie Brink," turned the scales in three successi weighings at 77, 59, and 52 lbs. On this occasion the enti body of the medium was dematerialized. Col. Olcutt say "The spirit came out again, and then I entered the cabin looking carefully everywhere, and feeling cautiously b thoroughly all about, but, as before, *finding no vestige* *the medium.* The chair was there, but no bodily presen sat in it." (*Ibid.*, p. 487.) The medium had been tied the chair at the start in such a way that she could not g free of her own motion and by ordinary means witho bodily injury. Everything outside the cabinet being plain visible and the house entirely devoid of any trap doors which she could have escaped, even if she could have free herself from her bonds, the medium beyond a doubt h become invisible and intangible; and yet a portion of h substance had been transmuted, had taken human shape, b an entirely different shape from her own, and with a weig about one half of hers. Small wonder that, after such extraordinary performance as this the medium, after t phantom had vanished, was found in her chair, tied as first, but "cold as marble, her eyeballs turned up benea the lids, her forehead covered with a death-like damp, no breath coming from her lungs and no pulse at her wrist. . . . She lay thus inanimate for eighteen minutes," life gradually returning. (*Ibid.*, p. 488.)

Not only has the flesh of the medium been dematerialized and then rematerialized, at least in part, in to shape not her own and capable of independent motion and speech, but apparently ordinary matter, not organic, can be dematerialized. An instance of this has been given by Dr. Hare's experience. Another was shown to Col. Olcutt with Mr. Horatio Eddy for medium. A welded iron ring was held by a spirit hand against the medium's arm, when with a tremendous shock, either the arm was dematerialized, allowing the ring to pass through it, or else the metal was as thoroughly dematerialized as if it had been vaporized and again condensed, for, after the shock, the ring encircled the right arm of the medium and slid down on the Colonel's wrist, he having tight hold of the medium's hands at the time. (*Ibid.*, p. 260.)

Col. Olcutt at the time of these experiments was a newspaper reporter, assigned to such duties, and with sufficient experience as a detective to be on his guard against deception. Later on, he came under the influence of that powerful hypnotizer and unscrupulous trickster, Madame Blavatsky, of whom Mr. Home, who saw through her, said that she was a deceiver. A no-less-gifted psychic and trained scientist than the honored Dr. Anna Kingsford, was for a time carried away by Madame Blavatsky's persuasiveness, but soon repudiated her, as did the British Psychical Reseach Society. Col. Olcutt was not fitted to cope with so subtle a personage. Besides, through long familiarity with the marvels of Spiritualism, he had probably become lax in his critical attitude. But the Eddy brothers were simple and very ignorant people, who were quite incompetent to perform tricks of legerdemain, and Olcutt was at that time a keenly critical young man who could have outwitted them if they had attempted anything of the sort, which they never did. Apparitions quite similar to those attending the Eddy brothers, though perhaps less varied, have been witnessed in the presence of the Polish medium, Franck Kluski, as described by Dr. Geley, and even without the need of the medium being in the trance state. Kluski conversed with his phantoms. As a child, he could separate the "astral" body from the flesh, leaving the latter in bed and traveling to considerable distances. When in the woods as a child, phantom animals would form a circle around him, to the great delight of his brothers and sisters.

CONCLUSIONS TO BE DRAWN FROM THE FOREGOING IN RESPECT TO MIRACLES

The objections urged by materialism against the miracles recorded in the Word of God fall before these modern miracles—instances which meet the objectors demand for something which can be recorded by a non-sentient apparatus. Science must accept and wrestle with these new properties of matter. It is now permitted to enter into the mysteries of matter and their connection with spirit. The discovery of America fades before the "new world" thus brought to view. The chief argument urged against the Scripture account of the Virgin Birth of Jesus is that miracles do not take place. But we have seen that miracles can and do happen. Ordinary birth can not be understood without the knowledge that spiritual substances are mingled with natural substances in nature. This knowledge has been revealed through Swedenborg and is now confirmed by the fact of materialization.

When the risen Jesus stood in the midst of the disciples, "the doors being shut for fear of the Jews," it was a Divine materialization. The Church, as well as Science, has something to learn from these disclosures. We know from the continual experience of Swedenborg during many years and from our own occasional experiences, that the spiritual sight can be opened during the earth-life, enabling us to see some of the objects in the spiritual world. But such is not the source of the experiences we are considering. Though produced by spirits, the things are perceived by the natural senses. Neither are they to be confounded with hallucinations, or deceptions produced under hypnotic influence, where the magician imposes his will upon another and makes that person imagine and temporarily believe that he sees things which are nonexistent. Photographic plates and platform scales can not be hypnotized. The materialized spirit, Honto, cuts off a lock of her hair and gives it to a beholder—hair which, at any rate endured for at least two years and which was pronounced by a hair-expert, who was ignorant of its origin, to have certainly been taken from the head of an Indian. And yet Honto, on another occasion, having staid out too long and feeling the need of replenishment of her energy by contact with the medium's body, while hastening back to the dark cabinet, failing to reach it in time, collaspsed into a little shapeless heap on the floor. But after renewing her strength from the medium, in a few minutes she was out again as lively as ever. Similarly, Professor Crookes narrates that Katie King, the materialized spirit with whom he conducted experiments during three years, lost her power at one time and appeared to sink into the floor, until only her head remained upon the carpet.

The question may be asked: Are these things evil? I answer: Not necessarily. A deceptive magic, or one which is used to support and inculcate false doctrines, is evil, for we are commanded, not to bear false witness. The use which is made of such practices will determine their status. When Jesus was accused of necromancy, He said:

"If I by Beelzebub cast out devils, by whom do your sons cast them out? But if I by the finger of God cast out devils, then is the kingdom of God come upon you." (Luke, xi, 19-20.) Surely we can not deny the presence of the Spirit of God, that is to say, of a pure motive, when a medium is permitted to give a healing touch, or where the spirit of a little child, who has passed into the spiritual world, is allowed to materialize and give comfort and joy to a weeping mother. It is equally permissible to use these things to elucidate scientific truths in regard to the nature of matter or the structure of the human body and its psychic connections.

But the case is quite different where the performance of miracles is cited as an evidence of the truth of what is taught by partisans of a cult. In his little work, *De Miraculis,* Swedenborg sums up the matter thus:

"I. Miracles were done in the Church before the Lord's Advent, because they were then external or natural men. . . . II. After the Lord's Advent when man . . . became internal, . . . miracles have been prohibited . . . III. Miracles would abolish worship truly Divine, and would introduce the former idolatrous worship, as also has been done for many ages back."

Examine, if you will, the worship of those ecclesiasticians which present miracles as a testimony to the truth and sanctity of their teachings, and see if they are not idolatrous.

GENERAL CONCLUSIONS IN RESPECT TO THE INTERMEDIATE SUBSTANCE BETWEEN SOUL AND BODY

In considering the scientific aspects of the subject, one can not help speculating on the final outcome of this new chapter in the theory of matter now opening. It has been stated that a slight, but noticeable diminution of the weight of the body occurs at the moment of death. The observation may not be easy to make at such a time, but it ought in any case to be continued for a much longer duration of time.

Swedenborg tells us that occasionally there is immediate separation of soul and body at death, especially if the death be a violent one; but he assures us from his long experience in the spiritual world, that usually the spirit is withdrawn from the body on the second or third day. This is also the testimony of Scripture: "After two days will He revive us; in the third day He will raise us up, and we shall live before Him." (Hosea, vi, 2.)

In his anatomical writings, Swedenborg teaches that the "animal spirit" is separated from the blood in the brain, flows through the system of the nerves, and is then restored to the blood. He also asserts that the ductless glands, of which the brain itself may be considered to be the chief example (although not called by that name) secrete substances which are essential to the life of the body. This is now confirmed by the discovery of vitalizing substances called hormones (and their antagonistic chalones, the activating and inhibiting agents of many vital functions) and the vitamines. The animal spirit is usually identified with the nervous fluid in the ventricles of the brain, but this is perhaps a wrong identification. This fluid is small in quantity, has but little circulation and appears to serve the purpose of a lubricant. Such a lubricating fluid is needed in the intimate motion of the brain and all of its parts, which

Swedenborg discovered and found to be synchronous wi the motion of the lungs. The animal spirit is indeed d scribed as a fluid and Swedenborg assumed that the ner fibers must be tubular in order to permit its passage, bu except in a very few cases, the nerve fibers are not tubul but consist of solid rods of a gelatinous substance. Tl nature of the transmission of nerve force is still a subje of investigation. It can not be electric, in spite of the r semblance of its function to that of a system of telegra wires. Professor Lillie has given reasons for believin that the action consists in the transmission of a wave chemical metabolism, with various catalytic possibilities, b this hypothesis leaves us not very much wiser.

CAN THE LIVING AND SOLID NERVE-SUBSTANCE BE DEMA TERIALIZED AND FLOW?

If the living nerve substance is capable of passing into dematerialized state *within the body* (and the extraction such a substance and its exhibition outside the body in th materialization phenomena, favors such an assumption then the solid nerve substance, under the incitement an guidance of the spiritual body, can *flow* by a mode whic involves the intimate connection of the soul which is or ganized *and organizing* spiritual substance, and the bod or material substance, through the limbus, or intermediat substance, which can alternate through various phases o materialization and dematerialization.

THE GUIDING POWER OF ORGANIZED SPIRITUAL SUBSTANC

The spirit of man is the enduring part of him. Durin a long life on earth man's spirit takes on and puts off man successive material bodies and still retains throughout al of these changes its own individuality.

The source of all life is the perpetual influx of Divin uncreated life into nature through the Spiritual World. This it is which directs the evolution of life-forms toward a definite end,—not by hit-or-miss saltations or "mutations" of De Vries and the "natural selection" of Darwin, but by a systematic urge along a given line as Waagen suspected. The natural selection of Darwin and Wallace, the efficiency of use predicated in the Lamarck-Spencer-Cope theory, physico-chemical forces employed in the ways described by Osborn,—all of these may serve as *means* for producing changes, but they are all overruled by a *spiritual selection* which is not fortuitous and which is truly the *cause* of evolution

The general impotence of natural selection to play more than a very subordinate part in the production of evolutionary changes is thus shown by Osborn:

"The general fact that the slow-breeding elephants evolved very much more rapidly than the frequently breeding rodents, such as the mice and rats (Muridae), is one of the many evidences that the rate of evolution may not be governed by the frequency of natural selection and elimination. For example, in the murine family of rodents, the annual progeny is very numerous and reproduction is very frequent, while among the elephants there is only a single offspring and reproduction is comparatively infrequent, yet the grinding teeth of the Proboscidea evolve far more rapidly and into much more highly complicated structures than the grinding teeth of any of the rapidly breeding rodents. If evolution were due to the natural selection of these variations this would not be the case." *The Origin and Evolution of Life*, p. 271-272.)

Similarly Weismann's law of the continuity of the germ-plasm (chromatin) gives a physical basis for the long enduring preservation of particular traits but does not ac-

count for the beginning of new ones. "One breath ca
not blow hot and cold." More potent in this direction
the Neo-Lamarckian assumption of the value to the orga
ism of useful activities in guiding the life-currents, b
Weismann showed that even here, there is no immedia
effect; and while there is some evidence that such use-pr
ducing changes accumulate and leave their mark after man
generations, this is not invariably true. If the desire
guiding spiritual urge is lacking, mere mechanism is i
effective.

The principle of "mutual aid," appealed to by Kessle
and Kropotkin, draws its strength from the love of ass
ciation which in both animals and men is more efficaciou
than Darwin's "struggle for existence" to decide the fa
of races.

Each animal has its love, each plant its appetite fo
drinking in sunlight and moisture. These and the leadin
principles enumerated above are the outward factors mak
ing for development; but something more is needed to co
ördinate them. Dr. Noel Reichardt called attention to th
significance of the *life-wave,* that genesis of a new for
which after some ages attains a maximum either of pe
fection, or of numbers, or of both, and then passes on t
extinction or at least to insignificance and is superseded b
something different.

Dr. Reichardt suggests that there were *two* germ-plasms
one of which was unaffected by local vicissitudes but passe
on a virginal impetus in all its purity, increasing in powe
until the force of the wave was spent. This was wholl
speculative. No such "second" germ-plasm has ever bee
discovered. But I would suggest that the spiritual sub
stances mingled with the natural in nature constitute jus
such an invisible directive force. The archetypal form

exist already in the world of causes, the Spiritual World, awaiting the assembling of the requisite conditions for their reception in the world of nature. Whenever a life-form has outlived its usefulness, it is wiped out and superseded by a better one. If earth-dwelling man can by selection produce better varieties of plant and animal life, surely angelic wisdom, backed by the Divine Power, can evolve the miraculous progress which we see in nature.

Undoubtedly there has been among living forms a "survival of the fittest," as Spencer said; but Swedenborg shows that, before there can be the quality of fitness, there must be first a Divine Providence foreseeing the need of and preparing for the existence of the innumerable forms whose harmonious interaction is necessary for the endurance of even the simplest organism.

The fact of evolution or the progressive development of plants and animals through the ages from simpler to more complex and more highly cephalized forms, is demonstrated by the long procession of paleontological sequence of organisms and by the wonderful series of changes in the course of development of individual embryos of the higher animals which repeat and recapitulate the history of untold ages. As to the inception of life on this planet, it seems as if the conditions needed for the direct transition from inorganic material to life-forms must have passed away in the early ages. Certain very simple unicellular organisms (bacteria) feed upon inorganic material but do not seem to originate from it; because if a solution of the material (whether inorganic, that is, mineral, or organic, that is, produced by living things though no longer alive and therefore not intrinsically different from mineral matter) is thoroughly filtered and suitably enclosed to prevent the invasion of seeds, eggs, or germs, it remains indefinitely witl out the least sign of life.

Swedenborg supposed that flies, moulds, and other o ganisms found in putrefying matter were generated *de nov* in this respect not differing from the universal opinion o his time. Decisive experiments were not tried until nea the close of the nineteenth century, with the result a stated above. Further experiments may reverse this de cision by showing that something essential to the inceptio of life has been omitted. This something may be physica or chemical conditions which have passed away in natur or it may be that spiritual conditions have changed. Th latter certainly seems to be implied by the instruction which Swedenborg received from the angels and which i thus given in *True Christian Religion,* n. 78:

"Because [God] is omnipresent such Correspondence [as the various animals and plants which had been show in the Spiritual World] exist in the whole natural Worl from the affections of His Love and Wisdom; while in ou World which is called the Spiritual World, exist simila correspondences with those who receive affections and per ceptions from God. The difference is, that in our worl such things are created in a moment by God according t the affections of the Angels; but in your World they wer at first created in an analogous manner; but it was provide that they should afterwards be perpetually renewed by the propagation of one from another, and that Creation shoul be continued in the same way."

I have given a literal translation of the last part of this passage which is very important because it has been otherwise translated by some scholars who seem to have thought that, in view of Swedenborg's opinions expressed elsewhere, it is necessary to retain somehow the idea of special or mmediate creations. But the instruction by the angels is xplicit, namely, that while there was such immediate crea-ion "at first," just as there is continually in the world of pirit, this mode of creation ceased in the natural world fter the earlier ages, and in its place was given *creation* (that is, creation of new forms and not just multiplication) y means of *procreation.* This is absolutely in accord with he modern scientific doctrine of evolution.

The only question which remains to be considered is as o *how* evolution is caused and proceeds, and here science as no accepted doctrine and should be open to suggestions.

The present opinion of science is that evolution proceeds y the accumulation of small variations. Some variations vhich are more notable than others are called mutations ut, while it is conceivable that a mutation of undoubted pecific magnitude may sometime appear, we do not antici-ate such extraordinary variations from the usual quiet and radual progression. We do not expect a frog to give birth o an ox. It would surely burst as in Aesop's fable. Nor s it reasonable to suppose that an animal of high order ould have come from a plant. The animal soul and the lant soul are too different. If the vegetable and animal ingdoms were ever connected, it must have been when rotozoa were hard to distinguish from protophyta.

As to the *cause* of evolution, and by evolution I mean God's nethod of creation which is *never* by letting a blind chance ule but which follows always a well ordered plan, ever ooking forward to creation's supreme end which, as Swe-lenborg shows, is *man* and which in all things regards he eventual production of a heaven of angels,—we have lready indicated that *origins* must be looked for in the vorld of causes and are in all cases spiritual, though we ometimes, speaking in an inexact way, call one of the steps in a sequence of effects the "cause" of what come after. Natural science seems to be gradually approachin this position, though still somewhat disinclined to abando the search for some self-winding clockwork! some mechan ical principle which shall give a machine-made solution the problem! By all means let the search for mechanis go on, but when found, no matter how perfect the engin it will require an engineer.

Professor E. B. Wilson in *The Physical Basis of Li* (New Haven: Yale University Press, 1923), after descri ing the marvels of cell-structure and cell-development, an after relating the discoveries in experimental embryolog by Driesch, the Hertwig brothers and Boveri, says:

"To the developing organism, it would seem to be all on whether it builds with one egg, two eggs, or a piece of a egg. How shall we deal with these facts under the mechan istic assumption of an original fixed structural pattern in th egg, Or, if we prefer the other horn of the dilemma, grant ing that the egg can at will make over the original patter so as to fit a new emergency, what kind of original con figuration in the germ makes possible such an operatio and determines its character?" (*Op. cit.*, p. 44.)

Swedenborg gives the answer. The essential organism i a *spiritual* form woven by the "simple fiber" in which th atmosphere of heaven flows. This form is capable of cloth ing itself with matter, whether from "one egg, two eggs, o a piece of an egg," just as we have seen that the spiritua body of a discarnate spirit can clothe itself with matte from the body of a medium and materialize a body of fles with a beating heart, with nerves and muscles which ca execute complicated movements (for example, the material ized spirit "Honto" in the séance described by Colone Olcutt sits down at the organ and plays a tune); and thi ody is doubtless provided with all of the intricate cellular tructure of a human body. All of this "mechanism" is roduced instantaneously, as it were "out of thin air"! t looks as though it were self-existent, but nevertheless it raws upon the unmeasured resources of the invisible spiritual powers, dependent on the great Source of uncreated life.

Dr. Wilkinson, more careful in his logic than his fellow cientists, insists that the succession of natural organisms 1 past ages was not evolved from matter but *de*volved hrough or by means of matter, from spirit. And he instances the materialization phenomena as a proof that this ethod of creation of human forms is entirely similar to he normal one. He says:

"Now strangely enough the phenomena called in the ggregate Spiritualism, have furnished incontestable examples of a contrary mode of Evolution, and it is a wellnown circumstance that more than one renowned Naturalst and Darwinian Evolutionist has witnessed these peculiar acts, and endorses them. The production of spirit Forms, rms and Hands, which has occurred to Séance-People vithout doubt or question, furnishes a more ready way for he appearance and materialization of organic forms, than he slow and altogether assumed mode of protoplasm truggling upwards through infinite ages into Lions and lephants. I have seen such things, and they were instananeous, and as good specimens of organism as any beast r bird on earth. Here is a method of production from he other side of the walls of nature, which might coach the cientist fancies to a better view of spiritual forces. Of ourse the appeal can only be made to those who concede he existence of these spiritualistic marvels. But it is rearkable that these persons have not made use of the coneption of devolution which such instances portend. Moreover, the history of the appearance of persons to the friends at the moment of death, shows the production o human forms complete in a moment, and attests that th nature of the world is very ready to conceive and operat such organic forms." (*The Greater Origins and Issues o Life and Death,* p. 26-27.)

When we consider that each one of us begins life as single-celled animal, the conception, development and birt of a little child is a perpetual Divine miracle. We inher the experience of ages of animal evolution and can sa with the poet Spenser:

> "For soule is forme and doth the bodie make."

(Hymne in honor of beautie, l. 133.)

The poet's fancy has penetrated the mystery. But Swedenborg goes farther and with his "scientific use of th imagination," his organon of discrete degrees, his knowledge that the spiritual world is not in space, he is able from experience to show that the spirit is an organized form composed of spiritual substances, which puts on a garb o matter and anon puts it off again, but retaining all of th discipline which it has received in this "intercourse" o soul and body.

The experiments of recent psychic science have brough many confirmations of Swedenborg's doctrine and hav made known the existence in the human body of an organized substance capable of being either materialized or dematerialized, capable also of being separated from the bod of gross matter and, when so separated, capable of bein borrowed by a discarnate spirit and used to manifest hi or her personality. This organized substance appears t be the same as that described by Swedenborg—the fundamental or basic substance of life, far more potent tha any protoplasm can be, which is constituted of that "simpl fiber" in which can flow the atmospheres of heaven, but which can serve as a nucleus around which material particles can gather. He has also given us the rudiments of a science of forms which alone can enter into and take possession of the aforesaid scientifics.

CHAPTER VIII

SWEDENBORG AS METALLURGIST, CHEMIST AND GEOLOGIST

CHEMICAL technology has been practised for ages. Th ancient Egyptians had the arts of making pottery an glass, that of embalming, also the manufacture of paint and the extracting of certain metals from their ores, a well as the production of leather, etc.

Iron, copper, lead, tin, gold and silver were known t the Jews in ancient times and they no doubt acquired th knowledge of the metallurgy of these substances while the were in Egypt, if not sooner. The name "Chemistry" embalms the fact that this science arose in Egypt, since i seems to have been derived from Khemi = Egypt.

Swedenborg was an adept in chemical technology an metallurgy, as witness his work on salt and his voluminou treatises on the metallurgy of iron and copper, which wer not only the first exhaustive accounts of these processes but were for a time the only ones in existence, and th foundation of their successors. In their production, Swedenborg travelled all over Europe, making notes of new methods wherever he went; and as Assessor Extraordinary of the Royal College of Mines in Sweden, in whose interes he made these collections, winning thereby the esteem an gratitude of his colleagues, he was in touch with all matter in the kingdom relating to mining and metallurgy. Though the son of a bishop, Swedenborg was descended from a long line of miners and mine owners, and he seems to hav inherited a special predilection for these studies.

In a recent summary of the history of the metallurgy o

on, issued by one of our leading manufacturing concerns,
wedenborg's treatise is noted as marking an epoch.

The work is illustrated by detailed drawings of various
inds of furnaces used in the smelting of ores and in its
irections for procedure it is thoroughly practical. The
easons for some of the processes may not have been under-
ood, but they worked. How far the improvements in the
ethods were original with Swedenborg I can not say; but
e had already attained eminence as an engineer by his in-
ention and construction of a ship railway, by his invention
f the air-tight stove, and by helping Polhem in his im-
rovements in the construction of docks. Presumably some
f the metallurgical processes were also indebted to his
enius. At any rate, he was the first to inform himself by
xtensive travel in regard to the actual state of the art and
 gather together a wide range of information.

That he had reason to blame his countrymen for their
lowness in appreciating his metallurgical genius is shown
y his recommendations being laid upon the table after he
ad urged them on various committees of the Diet for three
nd a half years.

When the Swedish Royal Academy of Sciences was
ounded by Swedenborg, his cousin, Linnaeus, the botanist,
he mathematician, Celsius, who invented the Centigrade
hermometer scale, and a few other, there were not many
rained scientists in Sweden. But eventually his metallur-
ical wisdom was accepted, and "Swedes iron" became
he most celebrated throughout the world.

The aim of the author in his metallurgical treatises is
iven in his preface to that on iron:

"I intend to distribute the treatise on each metal, as here
pon iron, into three divisions. The first division will com-
rise the processes and methods of smelting, particularly

that in use in various parts of Europe; and as the metho in vogue in Sweden have come more under my own obse vation than those employed in other countries so I will dw upon them longer in proportion. The second division w give the various methods of assaying; by which the ore tried in small fires, or assaying furnaces, and its compositi examined, in order that it may be better proceeded with a great scale. The third division will embrace an accou of all the different chemical processes that have fallen und my notice, with the characteristics of each; and will deliv numerous experiments and observations which have be made on one and the same metal in the course of solutio crystallization, precipitation, and other chemical change

This was a truly Baconian or experimental program.

When their merits became fully recognized, the metallu gical treatises were accorded high honors by the learn societies of Europe. That on iron was translated in French and incorporated as a whole in the "Descriptio des Arts et Métiers." A new mode of treating copper or was described and advocated in the treatise on copper.

Though his researches on minerals had to be mainly wi the occurrence of ore-bodies, Swedenborg noted a numb of facts pertaining to the then unborn science of geolog From marine fossils found far above present sea-level, an other facts, he gathers that Sweden must have been a island in earlier times, and the sea at a higher level. H speaks of the sea as having "subsided," evidently regardin the land as a fixed object and the sea as the variable thin We now know that the sea-level is relatively constant, whi the land rises and falls in respect to this level—here a ris and somewhere else a fall. He discovers the bones of a extinct whale, now called by his name. He speculates as t the cause of the great masses of glacial-drift pebbles i weden and is at one time inclined to attribute them to the niversal "Deluge," in which everybody then believed. fterwards, he showed that, while there may have been ocal deluges, the event described in Scripture was wholly llegorical. That there have been local deluges from time o time, such as that which attended the breaking up of the ast "Ice Age," which caused great inundations in Siberia nd extensive floods in the Mississippi valley, and else-vhere, also such catastrophes as that described by Pro-essor Fessenden in his work, *The Deluged Civilization f the Caucasus Isthmus,* can not be doubted; but a simul-aneous deluge over the whole earth is wholly mythical.

Still searching for the cause of the drift-pebbles, but not ecognizing their complete difference from ordinary beach ebbles (a fact which escaped attention until pointed out y that acute observer and expounder of glacial theory, ouis Agassiz), he surmises that the moon was formerly ear the earth and that the power of the tides was then nuch greater, with correspondingly greater attrition of hore material. We are now of the opinion that the moon vas, indeed, much nearer to the earth in far distant ages, nd that the tidal reaction has driven it away and slowed lown its rotation until the times of orbital revolution and liurnal rotation coincide. But this has nothing to do with he drift.

He alludes to the "supposed" age of the earth in terms vhich imply that he is beginning to doubt the truth of the hen currently held supposition that the earth is only a few housand years old. He lets his fancy play with the idea hat there were two marvelous trees in adjacent groves from vhose buds, miraculously nurtured, sprang the first human air. All nature served them. Spiritual beings waited on hem and instructed them, until at last they were ready to

meet and become the first wedded pair. But this is n
natural science. It is a beautiful fairy tale—spiritually fu
of heavenly meaning, but not to be taken literally. Lat
he learns that there were pre-Adamites, and after the open
ing of his spiritual senses, he is shown their spirits in th
spiritual world. "I was shown of what quality were th
pre-Adamites who were regenerated by the Lord and calle
Adam. A certain one spoke with me in such speech a
characterizes their life; not a rapid and distinct speech, a
is customary, but one whose words had in them a little o
life so that it can be heard. I heard him speaking when
awaked in the night; he was placed to guard me, and sai
that the evil wished to carry me off. I heard that he wa
such a guard, and was not evil." (*Spiritual Diary*, n. 3390.
The first chapter of Genesis is a Divine parable and tell
how from the life of a beast, man was raised to human an
then to truly heavenly life. We get the idea that this spiri
having "but little internal life" but "not evil," had bee
one of these primitive men.

Beginning to study Genesis, at first with the idea that i
must be literally true, he experiences a momentous change
A new light breaks upon his mind. He sees that the earthl
paradise is a symbol of the heavenly paradise into whic
the regenerating soul enters. He sees that he must begi
all over again. He has found a new world.

It would occupy too much space and would serve no use-
ful purpose to quote from the metallurgical treatises, which
valuable as they were in their day, have now been super-
seded by the publication of new and improved methods
What we most wish to know are the great principles o
pure science which remain as a precious heritage throug
all the ages and all the vicissitudes of varying procedure
in the arts. And here we are indebted to Swedenborg in

no ordinary measure; for he begins his great treatise on metallurgy with an introductory volume—the *Principia*—which will remain forever one of the immortal works.

This was preceded by an earlier and much smaller work, *Principles of Natural Philosophy,** which dealt largely with chemistry, or what was called by that name; but inasmuch as the pure science was then still in a preliminary stage, so that real chemistry can scarcely be said to have existed before Scheele and Priestley isolated oxygen, and Lavoisier demonstrated the existence of the chemical elements, or possibly not until the memorable work of Berzelius and Davy, that which Swedenborg calls by this name must be accepted with many excuses and admissions of imperfection.

We may note that he deprecated the waste of time which was then made in fruitless efforts to transmute "base" metals into gold, that his special interests were with the practical and useful arts, and with the effort to elucidate true general principles. If some of the latter were inadequate, blame must be cast on the then existing backwardness of experimental investigation which demands the united efforts of many searchers, an investigation which was barely beginning to show results; while chemistry, at any rate, was still hampered by the almost universal prevalence of false and grotesque notions. That Swedenborg was not entirely free from some of these, we shall see.

In trying to work out his initial conception that somehow the elemental world must be subservient to the laws of geometry, our author was led to postulate a primeval ocean, whose particles—first condensed, and then broken up by the great pressure in the depths of the sea—were rearranged in diverse geometrical patterns to form as many different kinds of particles of the final chemical elements. Thus the first member of the developing series according to him, was sea salt, formed from comminuted particles of condensed water in the depths of the sea. We are told that "9 particles of common salt are produced by the disintegration of 25 particles of water." (Part xi, Art. 1, Item 10, Strutt's translation, p. 35.) If this were indeed so, since the molecular weight of water (H_2O) is $2 \times 9 = 18$, that of common salt should be $2 \times 25 = 50$, if the distinction between the two were that of equivalent numbers of equal component particles, when the weights would be inversely as the equivalent numbers of compound particles concerned in the transformation. But actually the molecular weight of common salt (NaCl) is $23.00 + 35.46 = 58.46$, or nearly 17% too large for the hypothesis. Since the figures just given are certainly right to less than 0.1%, the derivation can not be admitted.

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* Full title: "Specimens of a Work on the Principles of Natural Philosophy. Comprising New Attempts to Explain the Phenomena of Chemistry and Physics by Geometry." Published at Amsterdam in 1721. A selection from this and other treatises, translated by Strutt and labelled "Principles of Chemistry," appeared in 1847.

The assumed derivation takes no account of possible change in volume of the parts, but goes on the supposition that the volume is simply dissected anew on geometrical lines and rearranged. Since, volume for volume, salt is nearly 2.2 times as heavy as water, supposing he is speaking in terms of volume, 9 parts by volume of salt are equivalent to 19.8 parts by volume of water for equal weights, instead of 25. Since the hypothesis does not agree with the facts on any mode of interpretation but breaks down at the first step, it is unnecessary to consider the further steps in the imagined derivation of all other substances (including metals) from water through common salt. But something should be said concerning the origin of the conception.

In Part X, Article 1 (Strutt's translation, p. 28), we read: "Since the subtle igneous matter, set in motion by the solar rays, can not penetrate into the deepest parts of the sea, it follows; (1) That the fluid or natural position of the particles can not be preserved at the bottom of the sea, owing to the superincumbent weight, and to the deficiency of the subtle matter. (2) The position of the particles at the bottom of the sea is the next in order to their natural position; that is, it is the fixed quadrilateral pyramidal, because that arrangement is most nearly allied to the natural and fluid position, as the latter can not be converted into any other, on account of the weight above it."

The "fluid or natural position of the particles," mentioned as appropriate to perfectly fluid water, is that described as the eighth, or "fluid quadrilateral pyramidal" position, in which 68.8% of the volume is occupied by spherical particles in contact. Under pressure, this is said to be converted into the seventh or "*fixed* quadrilateral pyramidal" position in which the spherical particles fill 74.8% of the entire volume. These various positions may be compared with the "space-nets" of Bravais, of which the complete number is fourteen. Swedenborg gives his numbers to five significant figures, but since in making the computations, he takes the approximate value of $\pi = 3$ 1-7, which is correct to but three significant figures, the last two figures of his result are worthless. Another instance of slipshod mathematics is seen in his discussion of different sorts of piling of spheres, where his fourth position is identical with his third and the reasoning is incorrect. His eight sorts should be seven; but, as noted, this does not exhaust the possibilities.

By continued pressure at the bottom of a very deep ocean, the first solid particles are supposed to be still further broken up and their parts rearranged. The hypothesis assumes that there was originally only one kind of material substance which became diversified into many varieties by the geometrical forms and configurations of its broken pieces. It is further assumed that this process can only take place at the bottom of the sea where there is an absence of the interpenetrating elastic cushion of a hypothetical substance which is called "subtle igneous matter" which elsewhere prevents the particles from clashing. Although Swedenborg does not mention Stahl's "phlogiston" theory, which worked so much mischief for chemistry, retarding the development of the science for over a century, yet his "subtle igneous matter" is evidently entirely similar to phlogiston, and the whole of this vast speculation falls with the demonstration that there is no such "matter." Moreover, water has been subjected to pressures greater than those at the bottom of the sea and does *not* break up into salt.

Today we know that matter is not all of one sort, but that there are nearly one hundred distinct species of atoms. The differences are not due to varieties of external geometrical shape, as Swedenborg supposed, for the atoms are all spherical. (This statement does not deny the existence of the Langmuir "octet"; but these eight polar points are grouped around a spherical nucleus whose shape, given by the electronic revolutions, is the really significant thing.) The differences between the chemical elements are possibly due to the different amounts, arrangement and internal motions of a few component ingredients (at any rate not more than three in number) which weave a complex resembling Swedenborg's particles with internal bullae, as described, not in the "Chemistry," but in the *Principia.* But the emission of helium atoms from the radio-active elements and the phenomena attending the emission of canal rays, are the only facts which in any way favor this view, and these facts may be otherwise explained. The spherical atoms are, indeed, juxtaposed and grouped into innumerable configurations in the molecules of the various chemical compounds; but this is an entirely different proposition from Swedenborg's ascription of chemical properties to the external geometrical shape of solid individual particles.

One important principle, and only one, emerges from this mass of speculation in the "Chemistry," and that is the ascription of virtue to various systems of *piling* or position in solids composed of spherical particles. This principle lies at the very root and origin of crystallography, as is now abundantly confirmed by the new X-ray analysis of crystals. Some thirty years after the publication of Swedenborg's treatise, Lomonossoff arrived, apparently independently, at the same conclusion, namely, that crystals arise from the configurations of their internal particles and their arrangement in layers. Both Swedenborg and Lomonossoff, however, were deceived in imagining that the internal arrangement of the layers can in all cases be inferred from the external shape of the crystals. This is not necessarily so. Thus common salt which crystallizes in cubes, might be supposed (and was supposed by these authors) to be constituted of particles regularly arranged in completely rectangular piling. But although the atoms of sodium are thus arranged in its crystals, the strong chemical attraction of the interspersed atoms of chlorine in the chloride pulls the sodium atoms into the closer order of diagonal piling, attended by a certain amount of condensation of volume. The condensation is not sufficient to account for the whole of the observed contraction in the union of sodium an chlorine, but requires that the atoms themselves by the mutual pressure shall be still further condensed, as note (*ante.* p. 603.)

There is such a thing as atomic piling. The X-ray examination of crystals has demonstrated it. But these primitive atoms, and the electrons of which they are compose are far antecedent to the solid spheres of which Swedenborg speaks in his so-called "chemistry." The atoms an electrons are in perpetual motion. They correspond to hi "elementary particles," described in the *Principia,* but no to the solid spheres, "cubes" with concave faces, angula particles closely packed and dove-tailed together. Mus we then conclude that the aforesaid fixed forms are nonexistent? Not at all, for in the viscid colloid state, as i many obsidians and vitrophyres, also in basic porphyriti eruptive rocks which have not reached complete crystallization, because there has not been sufficient freedom of motion for the atoms to spring at once into their position i crystalline planes, the microchemistry of incipient crystal has now been pushed far enough to show that the first exhibition of structure in solids, or the first differentiatio of the incipient crystalline from the colloid state, consist in the formation of minute spherical bodies, called globulites, scattered through the magma. But no angular bodie are formed by the breaking up of the colloid substance intermediate between the spheres, as Swedenborg imagined Instead of angular aggregations, we find *angular arrangements of the globulites* which first aggregate into linea sequences, or margarites, sometimes passing into crystallin needles, or branching into dendrites which eventually form scaffoldings to be afterwards filled-in with crystallographically segregated substance in the formation of crystals.

The arrangement of particles which Swedenborg was trying to visualize was microchemical rather than stereochemical. The globulites contain large numbers of atoms. He was on the right track but failed partially, because observation had not yet supplied the requisite data for the birth of microchemistry.

With an exaggerated conception of the need of contiguity in the particles of each successive order among themselves, Swedenborg imagined that while there might be spherical particles in solid bodies, they must necessarily be conjoined by other solid particles having concave faces and various projections in order to fill up the interstices between the spheres.* He does not appear to have considered that the strength and solidity of such interlocking structures could be equally well obtained by the interaction of forces in moving particles. The splendor of his vision of interiorly moved particles has been overshadowed by the apparent subsidence of the motion to solidity and rest. He did not need to make this concession to appearances. True, the centers of the atoms in a solid are approximately at rest in respect to each other, but the intense activity of their inner substance still goes on. The electrons, the energy of whose whirling motions constitutes the mass of each atom, occupy about a ten-thousandth part of its volume. The spherical atoms are not in immediate contact. As soon as the atoms approach contact, enormous forces of repulsion develop, and the attraction which holds them together, as long as they keep their distance, is reversed.

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* This idea, namely, that the particles in solids must be closely packed and their geometrical shapes distorted by mutual pressure is not wholly extinct even today, although it appears to be demonstrated that the shapes of the atoms are determined by the circular, or nearly circular, forms of the electronic orbits, and that these can not be much distorted.

The supposed rest is simply the maintenance of position of equilibrium with oscillations about the mean position. We find that matter is an open-work structure. An atom being a swarm of rather widely separted electrons, we need not be surprised that an atom of helium shot off from radium at high speed (about 10,000 miles per second), can pass through many atoms before being brought to rest. Individual electrons of the β-rays penetrate to much greater distances and can pass through thin sheets of metal; and finally the γ-rays of the most rapidly vibrating etherions go through walls of solid stone as if they were only gossamer.

The proof of the sphericity of the atoms follows at once from the knowledge of the energy and high velocity of revolution of their electronic components. In Anderson's experiment, a few centimeters of very fine iron wire, electrically exploded, produced several cubic centimeters of iron gas at an estimated temperature of 20,000° K. and a pressure of 20 atmospheres. Here the atoms of the iron were hurled against each other with such power that the orbits of their mass-giving electrons were set vibrating and emitted a continuous spectrum extending far out into the ultra-violet and brighter than the sun's photosphere, crossed by fine absorption lines from a very thin outer and cooler layer.

In still more powerful explosions of fine tungsten wire, not only were the mass-giving electrons caused to oscillate so as to give out a blinding light, but the atoms themselves were broken up (into their subatoms?) and after the explosion nothing was found but a little helium gas, the product of the atomic disintegration.

The tremendous energy concealed within the apparently inert atoms is no longer in doubt, and in fact, the inertia itself arises from nothing else than the difficulty of altering the position of the excessively rapid electronic revolutions within the atoms. If it is a question of just disturbing the position of these orbits a little (involving the reversal of the gyrostatic axis of an electron or the tilting of the plane of a magneton), but of so profound a disturbance as to actually break up the entire configuration, thus transmuting one element into another, the operation can only be accomplished by the concentration of an excessively powerful electric discharge upon a fine wire, as described above.

Swedenborg's conception of a condensed particle containing internal small bullae (given in the *Principia* in his figure of a condensed air particle) would correspond very well with the idea of a complex atom, enclosing subatoms of hydrogen (Prout's hypothesis), or hydrogen and helium (Harkins *et al*), or of hydrogen, helium and nebulium (as suggested by the present writer from the three-fold decomposition of matter in the positive rays, as witnessed in the emanation from Nova Persei.) But while some such idea appeals to chemists, it does not satisfy the physicist, who finds evidence everywhere of electrons as the universal atomic constituents.

Still a different idea was put forth by Swedenborg in his earlier work on chemistry (only extant in a mutilated form.) This conception which predicated excessively minute *solid* spherical particles, grouped in spherical shells which were themselves similarly regrouped, thus forming successive orders of composed particles each one on a larger scale than its predecessor,—and then a breaking up of these particles by pressure into others of many shapes, was probably formed while he was under the influence of his teacher, Sir Isaac Newton. Though more complicated than Newton's little "solid, massy, hard, impenetrable, moveable Particles," the hypothesis has no real advantage over the other;

and Swedenborg's genuine contribution to chemistry did not come from this attempt to conceive of chemical properties as arising from the various shapes of solid particles in matter of different kinds, but was born out of his splendid suggestion (in the *Principia*) that there are different orders of elementary particles formed by exceedingly rapid vortical revolutions of still finer particles, also having internal structure and motion, thus invoking motion and energy as the basis of matter.

Some of Swedenborg's fallacies in his chemistry arose from poor observations. Thus in his chapter on "Properties of Water" (Principles of Natural Philosophy, Strutt's translation, p. 26) we are told that "in ice, the subtle matter collects into granules and innumerable globules. The subtle matter exists in great abundance in places which appear to be empty, sometimes like stars, at others like streaks, etc., perpendicular to the surface." (n. 35.)

A more refined observation would have disclosed that the "innumerable globules" in granulated ice are usually air bubbles from air dissolved in the water, while liquid, but separated during freezing. The stellate shapes in the interior of a block of ice are cavities filled with water, with a minute *bubble of vacuum* at the center (due to contraction in melting) produced by the local absorption of the sun's rays by individual stellate ice-crystals. These "ice-stars" or "ice-flowers," and their production are described in a most interesting way and illustrated in Tyndall's *Heat as a Mode of Motion* (p. 124-5, Fig. 33.) The confounding of these inclosures with the "subtle matter" of heat was a case of jumping at a conclusion from a preconceived but erroneous explanation. A very little careful observation would have shown the errors of these assumptions. But although the "subtle-thermal-matter" hypothesis could have been easily demolished by more critical theorizing and better observations, and although Mayow, who lived a little before Swedenborg, had shown that air contains two different gases, one of which is withdrawn in supporting combustion, that this substance is contained in saltpeter and, as he believed, in all acids,—the wholly erroneous conclusion that a certain subtle igneous matter is withdrawn from the combustible and vanishes into the air when anything burns, instead of the opposite fact that something out of the air unites with the combustible, lingered on for more than a hundred years. We have seen in Chapter VI that in the *Principia* a doctrine much nearer to the modern one is adopted, and heat is spoken of as "most intense central motion of the parts of air or ether."

EXAMINATION OF THE THEORY OF COLOR CONTAINED IN THE "CHEMISTRY"

There are passages in the "Principles" which throw light on the way in which Swedenborg derived his peculiar theory of color. Having observed that substances of very diverse colors appear white when ground to a very fine powder, and that a froth even of a colored liquid gives a white foam, or that pellucid bodies become opaque white when subdivided, he attributes the whiteness to a confusion of the paths of transmission of the light and then extends the principle thus:

"If the surface of the particles be variegated by particles of a different kind, the color red is the result," and this is "on account of the transmission of the rays through two kinds of particles." (*Prin. Nat. Phil.*, p. 131.)

Observing that melted lead, when heated in air for four or five hours, gains in weight (though losing in density) and changes to red minium, he continues: "All these results are signs that the particles of lead are extended into bullae in the same way as water particles into vapors. These experiments indicate moreover that new particles are created by the fire (as oils in the retort) which being transferred to the same surface of the bullae, and ranged around it, vary the light, that is to say, the transmission of the light through the bulla, whence the red and yellow colors." (*Ibid.*, p. 161 n. 3.)

Here we note that the lead is supposed to be first converted into minute bubbles (which, if it were admitted, might indeed account for the diminution of density) and then the surfaces of these bubbles are supposed to be variegated by still finer particles, and red is imagined to come from transmission of light through two orders of particles, as white results, according to him, from confusion or rays by a single order. Evidently this theory was not founded on color experiments. He starts with the obvious fact that a pellucid substance becomes opaque white by being comminuted into particles of a certain order of magnitude, and then extends this fact unwarrantably by the vague surmise that perhaps the admixture of a second order of particles might give red.

As to the experiment with the lead, if we were to substitute copper filings for the lead, the same oxidation of heated copper gives, not a red substance, but the jet black oxide of copper. Endless discrepancies would arise on further variation of the substances, which shows that there is no truth in the supposition. In fact we now know that color is produced by the absorption of definite regions of the spectrum by molecules whose structure permits them to vibrate to the given rays and turns them into heat, while the unabsorbed remnant is either transmitted or reflected. When recombined this remnant impresses the eye with the sensation of color; but without spectroscopic analysis, it would be impossible to discern the nature of the bundle of rays, because entirely similar combined color-impressions can be given by bundles variously compounded. The effect is also further complicated by physiological phenomena connected with the organ of vision. Since none of these facts were known in Swedenborg's time and no data existed on which a correct color-theory could be built, it is useless to go to him for information on color-vision.

The true explanation of the fact that even strongly colored media appear white, if the material is finely comminuted and illumined by white light, is this: The surface reflection of light from a given material is invariable, whatever its thickness may be. But its selective absorption of the light, on which its color depends, increases with the thickness of the layer and the light becomes vanishingly small if the layer is thin enough. In a fine powder, internal multiple reflections from particle to particle reenforce the reflected light and make a total which may approach 100 per cent of the original light, even when the reflection from a single surface is only a few per cent; but the absorption gets less and less as the size of the particles diminishes, and thus, if the incident light be white light, a sufficiently fine-grained powder may be of surpassing whiteness.

Coming next to Swedenborg's physiological writings we read in *The Economy of the Animal* [or Soul's] *Kingdom* (Clissold's translation, Vol. I, p. 57):

"When blood, divided into its particles or plano-oval spherules, is inspected through a microscope, it exhibits scarcely a shade of its proper color; and yet when a number of the particles are conglomerated, it assumes a hue of deep red. Since therefore the blood so remarkably distinguishes itself from the other liquids of the body by its various colors, it is of importance to the knowledge of the blood that we ascertain what color is, and whence it originates. Color, then, as we learn from phenomena, is a certain discrimination of light and shade, and a certain determinate ratio and analogy [ratio to what? and analogy with what?] thence arising in these extremely minute objects which do not come distinctly within the visual perception."

Here we must distinctly dissent. This vague and cloudy statement does not constitute a specification of the nature of color.

Swedenborg proceeds: "For in objects of this kind, the eye cannot discern between luminous and shady ways; wherefore it apprehends only the general image of the discriminations and differences, as represented under the beautiful appearance of colors." In this sentence, although no experimental details are given, there appears to have been a dim apprehension of what is now known as a fact, namely, that in the spectrum of light reflected from a colored body, or emitted from a colored luminous source, certain rays or spectral regions are not 'shady" but shaded, that is, they are wanting either because they were originally absent, or because they have been absorbed and converted into heat. But the eye, unprovided with spectroscopic apparatus, can not discriminate between these regions, though the resulting general sensation is that of color.

After some vague allusions to experiments with prisms, spheres of glass, etc., he proceeds: "From all which particulars severally illustrated, it may be clearly shown that in color there is nothing which is real, but that it is solely an illumination which is produced by the sun, candle-light, firelight ,and so forth, variegated according to the various constitution of the bodies interposed, particularly such as are transparent" [meaning that color is not a substance pertaining to the colored body, but is a variegation produced by the body on light which is not its own]. "With an attention to these principles, and after an ardent pursuit of this class of optical experiments, I have seemed to myself to have attained to the ratios of shades and lights by which single colors might be respectively designated, and in some manner also to the forms of the parts trajected by the beams."

Here he is hot upon the trail of a genuine discovery. The "ratios" of the numbers which give the wave-lengths of the rays are definite properties of the rays. Color and wave-length are interchangeable definitions of the ray of light; and the resulting color communicated to white light by passing it through "bodies interposed" is due to the striking out of certain groups of waves which are absorbed or used up in communicating resonant vibrations to groups of atoms (either molecules or parts of molecules) which are capable of vibrating to these and only to these frequencies. But unfortunately Swedenborg was diverted to a false scent and imagined, from his chemical fallacies, that his supposed, but nonexistent, geometrically and rigorously shaped corpuscles—trigons, prisms, quadrangles, and what not—were somewhat directly concerned in the production of color. We now know that a peculiar configuration of the spherical atoms, recurring in a variety of relative organic substances, produces, especially if the group be unsymmetrically disposed, a series of absorption bands in the spectrum which are nearly identical in position and extent. The configuration of the atomic group is of course geometrical, but its absorbent property has no relation to any fancied resemblance of its shape to a triangle or a square, but is wholly dependent on its period of vibration as a swinging appendage.

Continuing on his false trail, Swedenborg proceeds thus: "It is well known, that nothing produces with greater distinctness and nicety the diffierent ratios and forms of shaded light, than the volatile, urinous, alkaline and sulphurous salts as so many triangular, prismatic and quadrangular corpuscles, which, when they dispose themselves throughout any compages in an orderly arrangement, give rise to a general modification of color, either red, green, or yellow; and hence results the pictorial or scenic effect which is distinguished and comprehensible only by a general visual perception. This is more particularly true in the case of the blood, between the compages of whose parts interpose the volatile salts, from which the red color receives all its modifications; a color which is heightened and vivified in proportion to the interposition of similar minute particles in the less compounded blood, or in the spirituous fluid; which is enriched in proportion to their quantity; and is obscured in proportion as the congeries is disarranged by the intermixtures of heterogeneous and opaque substances that confound the discriminations of light and shade." (*Ibid.*, p. 55.)

This is wholly fantastic. Descending from these flights of fancy to an actual experiment by Leuwenhoek, we are told that he found that the blood globules "are colorless or quite transparent. If, however, a number of them be placed one upon another, they exhibit a reddish tinge." Here, instead of recognizing that the absorption of a single miscroscopically thin layer of even strongly absorbent substance is not sufficient to produce appreciable color, but that the color is intensified as the layer deepens, he attributes the color to intermediate "salts of the second order" interspersed between the blood corpuscles, and says: "For when they are in a state of mutual conjunction, immediately urinous or volatile salts of the second order interpose themselves." This simply is not so.

The existence of haemoglobin in the blood corpuscles, its identification by the strong absorption bands which it produces in the spectrum, its use as a carrier of oxygen to all parts of the body, after its oxidation in the lungs, all of this was then unknown. Swedenborg was attempting to make "bricks without straw" and landed in absurdities. It is of interest to ask whether his ideas about color were modified after the opening of his spiritual sight.

STATEMENTS CONCERNING COLOR IN THE THEOLOGICAL WRITINGS.

In *Heavenly Arcana,* n. 2519, we read: "The Divine can enter into the rational, but not the rational into the Divine; as the soul can enter the body, and form it, but not the body into the soul; or as light can enter into shade, and modify it into colors, but not shade into light."

Here a true science is needed to illustrate spiritual truth. The color is not in the shade, but the color is in the light and the sensations which it excites. The illuminated substance which, but for the light, would be completely shaded, simply selects out of the white light certain colors for reflection. In like manner the mind of man reflecting on the infinite truth of God, finds itself moved by certain aspects of that truth and selects what is in harmony with its own states. These partial truths "color" the thought.

The following is from *True Christion Religion,* n. 216: "Since the Word in its inmost depths, from its celestial Sense, is like a mild flame which enkindles, and in its intermediate depths, from the spiritual Sense, is like a light which enlightens, therefore in its ultimate, from its natural Sense, it is like a transparent Object receiving both, which from the flame is red like purple, and from the light white like snow. It is therefore comparatively like a Ruby and a Diamond, like a Ruby from celestial flame, and like a Diamond from spiritual light."

This does not involve any theory of color. The celestial sense of the Word is concerning the Lord alone. When He enters into the soul, His recognition is like the rising of the sun and the rosy light of dawn, and is so named in Scripture symbolism. There is a new day, a new enthusiasm from vivified affection. A flame of zeal is enkindled. But those who view the Word from its spiritual sense are intellectual and see in the clear white light of truth. They are not so apt to be carried away by enthusiasm, or to "view things through rose-colored spectacles." Everyone speaks of the "light" of truth, but light has many colors, as truth has many aspects. Only the light of the sun in a cloudless sky shows colors in all their perfection. Hence it is said of the sunlight of truth in the last words of David: "The Spirit of Jehovah spake by me. . . . He is as the light of the morning when the sun riseth, a morning without clouds." (II Sam., xxiii, 2, 4.) Black is nowhere mentioned here, because the Divine truth alone is described.

In *Heavenly Arcana*, n. 731, man's proprium is said to be "as if destroyed when it is vivified. . . . and yet it is not destroyed, but remains. It is almost as with black and white, which when variously modified by the rays of light, are turned into beautiful colors—such as blue yellow and purple—whereby, according to their arrangement are presented lovely and agreeable tints, as in flowers, yet remaining radically and fundamentally black and white."

Here, noting the "almost as with," we see that the words need not be taken literally. Yet even so, the illustration absolutely requires the true scientific theory to make it ntelligible. Man's proprium is what makes him his own peculiar self. He wills to be his own, to select what he shall have for his own. But man's proprium, the "shady" part of his being, has no *virtue* of its own. It is like a dull and colorless surface, "black and white," which has to be "vivified" by receiving colored light, or the power to produce such by modifying white light, *selecting* the color which it wills to make its own, or by which it will be known, but blotting out or being black to all other elements of color. In this way the flower, from the organic substances in its petals, sifts the sunlight and selects its own color.

Where the correspondence of the rainbow is given in *Heavenly Arcana,* n. 1042, we read:

"As to natural colors, the existence of color requires something both dark and light, or black and white. When rays of sunlight fall on this, according to the varied mingling (*temperaturam*) of dawn and light, or of black and white, from the modification of the inflowing rays of light, colors are produced, some of which partake more and some less of the dark and black, some partake more and some less of the light and white; and hence is their diversity. It is similar in spiritual things. The Darkness there is man's intellectual or false proprium, and the Blackness is his voluntary or evil proprium, which absorbs and extinguishes the rays of light."

These vague statements would be quite unintelligible without interpretation from scientific facts which are now well known but which could not have been stated in Swedenborg's time. His spiritual wisdom outran his natural science. That which produces natural color is the power to *select* out of a complex, certain colors which shall be reflected, suppressing the rest. Out of a mixture of black and white pigments, only a neutral grey is formed. The "varied mingling of dark and light" is not of that sort; but "the modification of the inflowing rays of light" is due to the varied mingling of the *qualities* of selective absorption and selective reflection which every substance possesses, depending upon the form and structure of the least parts. There must be substances without varying degrees of reflecting power for each sort of light, classified according to its position in the spectrum. The reflecting power varies from black which reflects nothing, to the purest white which reflects every ray, in order to produce the innumerable colors of nature. Given some original color, its modification by the varied mingling and dark and light may be scientifically illustrated by Chevreuil's color-charts in which, for example over a pure tint of red are printed various patters of black or white dots in greater or less profusion, and by the combination of these there is produced the effect of various modifications of the fundamental color from dark brown, with much of black in it, to light pink which is nearly white. A painter would, of course, mix black or white paint with the red to give the desired effect; but Chevreuil's scheme admits of exact quantitative gradation and scientific specification. Swedenborg's spiritual specification is equally exact, and this as to the most minute details of the light of Divine Truth, which blazes forth with the splendor of the sunshine, as in his explanation of the first verse of the tenth chapter of the Apocalypse. (A. R., n. 464 to 8.)

When Swedenborg was writing his science, the spectroscope had not been invented, the emission of definitely colored spectral rays by particular substances in flame spectra was unknown, experiments in physiological optics had not begun. No wonder his guesses at color-theories were bizarre and wholly false. But when he had been admitted into the light of the spiritual world, his new conceptions from the spiritual side are seen to be in harmony with a true natural science. There may be a slight lingering of the old hazy notions, as in Apocalypse Revealed, n. 915, where we are told that "There are two colors in general which shine forth through precious stones, red and white. Other colors, are green, yellow, blue, and many more, are compounded of those with the intervention of black." This simply is not so. By no "intervention of black" can green, yellow, or blue be produced out of red or white. We must therefore amend this statement in the interest of truth. But on the whole, there is a decided improvement in the theory of color as presented in the theological works.

In *Apocalypse Revealed,* n. 232, we are told that when the Divine sphere which surrounds the Lord appears in the heavens, it "appears in the heavenly kingdom to be red like a ruby, in the spiritual kingdom to be blue like the lapis-lazuli, and in the natural kingdom to be green like the emerald; everywhere with ineffable splendor and radiance"; as if these three colors were fundamental in the Spiritual World. We are reminded that the retina has color-sensitive organs of three different kinds, mingled with a fourth sensation which Prof. C. S. Pierce called that of "the color of brightness. In Mrs. Christine Ladd Franklin's color theory this fourth sensation is distinctly ascribed to yellow, and the other three are given as red, green and violet.

More wonderful were the things seen in the "rainbow heaven," ascribed in *Heavenly Arcana,* nn. 1623-1625, which might give suggestions to a composer of color-rhapsodies on the "color-organ." There are colors seen in the heavens "which have never been seen in the world," a statement which ought not to surprise us, since we know that the eye of flesh is sensitive to only a very small part of the entire range of radiant vibrations. We might even conjecture that on other earths, evolution may have produced physical eyes responsive to colors to which we are blind.

One other extract relates to an interview which Swedenborg had in the spiritual world with his old teacher, Dr. Isaac Newton. "Concerning colors, Newton said, that in the world he had believed them to originate from substances, or as it were variously colored matters which continually flow forth from the solar ocean. . . . But the Angels did not recognize this cause of colors, saying, that there are equally colors in the Spiritual World . . . and that they know them by the variegations of their light, corresponding to their love or good, and to their wisdom or truth; and that the Sun from which their light proceeds is the Lord Himself . . . and from that Sun, which is pure love, such substances or matters do not flow forth; but that pure light presents the variegations of colors in objects according to the reception of wisdom by the Angels; a red color in proportion as their wisdom derives from good, and a bright white color in proportion as their wisdom derives from truth; and the other colors as it were partake of their defect and absence, which correspond to shades in the world. Moreover ,the Angels . . . demonstrate that colors are nothing but variegations of flaming light and of bright white light in objects according to their forms; and that colors are not material. . . . After he had thought more deeply about the subject, he said: Now, I know that colors are modifications of light in objects, in the forms of which they make common planes, upon which the light is variegated according to the forms of the parts whence come colors. These are Newton's own words, which he wants me to communicate." (*Last Judgment, posthumous*, n. 267. Translated by Potts.)

In *Divine Love and Wisdom* we read:

"The blood is red by virtue of the correspondence of the heart and the blood with the love and its affections. In the Spiritual World there are colors of every kind. Red and white are the fundamentals of these; and the rest derive their varieties from them; and from their opposites, which are fiery dusky and black. The color red there corresponds to love, and the color white corresponds to wisdom. The reason why the color red corresponds to love is, that it derives origin out of the fire of the sun there, and why the color white corresponds to wisdom, is, that it derives origin from the light of the same sun. And because of the correspondence of love with the heart the blood can not but redden, and indicate its origin. Hence it is that in the heavens where love to the Lord reigns, the light is flamy, and the Angels there are clothed in purple garments; and in the heavens where wisdom reigns, the light is white, and the Angels there are clothed in white linen garments." (n. 380.)

Here Swedenborg is speaking spiritually and is using *correspondential* language. Red corresponds to love and white to wisdom. There are the fundamentals of spiritual life. He is also speaking humanly. The blood and flesh of the body are red. The brain and nerves are white. Consequently, when he says that red and white are the colors of heaven, he is talking symbolically. He is using the langauge of heaven. He does not mean that there are no other colors in heaven than red and white, for he says in the beginning: "In the Spiritual World there are colors of every kind." But just as to millions of men the flag of the red, white and blue spells freedom, so the colors of heaven thrill the hearts of all who know their import.

The angels of the celestial heaven may appear in purple robes and those of the spiritual heaven in white linen garments as a rule, or in respect to the general impression given, but must we suppose that they never change their garments but appear always in a stereotyped uniform? Certainly not. When the state changes and as often as it changes, the varying affections shine forth in the raiment with exquisite beauty. The myth about the harp and wings and golden crown as angelic accoutrements, has gone (*vide* Swedenborg.) We may be well assured that there is perfect adaptation of garments to wearer and no tyranny of fashion in the life to come.

"What makes the beauty of the face but redness and whiteness and the lovely intermingling of one with the other? Is not the redness from love . . . for love is red from its fire?" (*Conjugial Love,* n. 384^2.) Every artist will say, yes; but one need not be an artist to assent to all these things as being beautifully expressive of heavenly truths.

Because the chemist tells us that on the earth, the blood of human bodies is formed of substances which have been derived ultimately from the dead sun of *our* world, and that the blood owes its red color to an organic compound containing a little iron, are we called upon to deny all this poetry and beauty? Not in the least. The deeper we go into the mysteries of nature, the more intricate and wonderful shall we find the concealed mechanisms by which all of its workings are produced. Is it a question of iron in the blood? Iron represents natural law which must be obeyed, else we die. Whence is the strength of iron? From spiritual principles: Because obedience to the law of God gives spiritual power. Physically, because the atoms of the iron have a certain magnetic attraction for each other. But whence this magnetic attraction? Again, answering from spiritual principles, because love of our fellow men is the binding together of society. Society is a greater man. In the New Age which is even now upon us, the "man child" shall rule the nations with a rod of iron. Through the rule of an iron law, irrefutable but recognized as salutary, the unruly nations are to be brought into subserviency to the Divine government and the body of humanity into health. Iron in the blood! By its marriage union with the oxygen of the air it gives vigor to the system. Though we may not always recognize it right away, there is love underlying the iron law. This is the reason why the blood is red. Any lesser reason, good as far as it goes, fails to sound the depths of Divine philosophy.

We see that the statement that red and white are the two fundamental colors *in the spiritual world* must be true. But this is because the spiritual world is the human world. If we take this statement literally and physically and outside the human body, or where it does not apply, we shall be led into great error. If we take the statement as a literal fact of nature and assert that red and white are the fundamental *natural* colors, the statement is not true. The spectrum contains innumerable gradations of color, or if we group them into sorts which can be readily recognized and named, we have twelve colors, namely: deep red, scarlet, orange-yellow, lemon-yellow, citron, emerald green, glaucous blue, violet-blue, violet, lavender-grey, of which red is only one; and while the *sensation* of red is one of the three, or as some think, four fundamental sensations of color vision, we cannot lump the others together under the term "white."

It is interesting to learn from Newton's experience tha we can complete our knowledge and correct our errors i the spiritual world after death, at least to a certain extent Newton had taught that light is composed of hard materia corpuscles, and we have seen that at first he had suppose that there were as many kinds of corpuscles as there wer colors. But as is shown above, Swedenborg taught tha there was nothing "real" in color, by which he evidentl means nothing material. And now we learn that Newto abandoned his first opinion and that his final conclusion i that "colors are modifications of light in objects" and tha "the light is variegated according to the forms of the parts, which is a vast improvement, especially if the "parts" ar taken to mean atomic groupings in the molecules.

If we could only suppose that Swedenborg, when h asserted that colors are produced by the "mixing of blac and white," was groping for the idea of a blotting out o darkening of some of the colors of the spectrum, leavin the remainder untouched, this would be selective transmission (or reflection, as the case may be) of particula colored rays, which is the true cause of color.

With this conceivable interpretation in mind, let us rea again A. C., n. 1042 (quoted above). He says that natura colors are produced by the "modification of the inflowin rays of light" (that is, of spiritual truth.) Consequently part of this operation he actually says that it is the "ev proprium [of man] which *absorbs and extinguishes* th rays of light" (that is, of spiritaul truth.) Consequently if we allow the light of his illuminated spiritual vision t help interpret his natural science, his "mixture of black an white" becomes a selective absorption of certain rays by th colored body, allowing the remainder to pass freely, o being "white" to them, which is the true explanation o olor in natural objects. To be sure, the passage in which his occurs is about the rainbow, whose colors are *not* due o absorption but to separation by differential refraction, one of them being blotted out; but still, at this particular oint, he is talking about ordinary color in material bodies, hich alone can be likened to the phantasmagoria and eceitful camouflage of the proprium.

We may conclude from what has been shown in this hapter that Swedenborg had the idea of atomic piling in olids, now demonstrated by the X-ray examination of rystals; that he began to have perceptions of paleontoogical and geological truths; that he knew much about the ccurrence of ore-bodies, and as a practical engineer, that e inaugurated a new epoch in metallurgical processes.

We have devoted a good deal of space to a comparatively inor point—his doctrine of color—because its origin is o be found in the "chemistry" on whose fallacies it is ounded, and because it has puzzled many of his readers. he "conversation with Newton," which represents about is last word on the subject, will help to set him right.

CHAPTER IX

SWEDENBORG'S DOCTRINE OF FORMS.

SWEDENBORG'S Doctrine of Forms is unique. There is nothing like it in any other philosophy. The "forms" meant are not mere external shapes, but rather are internal structures, and more than this; they intercommunicate, for the knowledge given is that of connections which interweave and bind together the entire universe into a consistent whole. The Doctrine of Forms is therefore at bottom a *spiritual* law. It concerns the ways and means by which the Lord's Divine Providence unites all parts of His universe in law and order. Let us therefore start from the thought of this Providence.

"And the four animals had each of them six wings about him." (Rev. iv, 8.)

"Hereby is signified the appearance of the Divine Spiritual on every side around the Divine Celestial. The ground and reason why the cherubim as to their bodies, signified the Divine Celestial, and as to their wings the Divine Spiritual, is because all things by which celestial things are represented, as to the bodies themselves, signify things essential and as to the things which are about them they signify things formal." (*Apocalypse Explained*, n. 283.)

There are six proceeding spheres, or atmospheres, which are so many forms of activity by which the Lord provides for the creation of the universe as a basis for heavenly life. As there are six days, or states of ascending order, in the formation of the celestial church, so there have to be six distinct descending processes, each successively limited as to form and thence as to power in laying the foundations.

Wings denote powers, and the atmosphere over which the wings of a bird exercise power, is a form of energy on the lowest plane of creation. The higher atmospheres are powers, that is, forms of energy, less narrowly limited and arranged in sucessive degrees.

The higher forms of creation are more potent and more perfect. They penetrate, constitute, produce, and interiorly inform the lower ones. The higher forms interpenetrate and coexist in the Divine provision of harmonious structures which mutually assist each other and nowhere conflict. These interrelations have to be discerned by the aid of reason, when this is directed to the innumerable details provided by experience. Illustrations are given in Chapter I.

The following, which is quoted from Swedenborg's *Worship and Love of God,* contains a geometrical illustration:

"This form, which the stars with their universes determine or co-effect by intermixture and harmony with each other, and which on that account is called celestial [or galactic], can not at all be acknowledged as the most perfect of all forms in the world, if we depend only on the view presented to the spectator's eye on this globe of Earth; for the eye does not penetrate into the distances of one star from another, but views them as placed in a kind of expanse, one beside another; hence they appear as without order, like a heap without arrangement. Nevertheless, that the form resulting from the connecting series of all the starry universes is the exemplar and idea of all forms, may appear not only from this, that it serves as the firmament of the whole heaven, but also from this, that the first substances of the world, and the powers of its nature, gave birth to those universes, from which, and their cooperation, nothing but what is most perfect flows forth; this is confirmed also by the distances of the stars from each other, preserved for so many ages, without the least change intervening. Such forms protect themselves by their own proper virtue, for they breathe something perpetual and infinite; nevertheless, they cannot be comprehended as to their quality, except by lower or lowest forms, the knowledge of which we have procured to ourselves from objects which affect the sight of the eye, and further, by continual abstractions of the imperfections under which these forms labor. But let us view these forms in their examples: The lowest form, or the form proper to earthly substances, is that which is determined by mere angular, and at the same time by plane subjects, whatsoever be their figure, provided they flow together into a certain form; this, therefore, is to be called an *Angular Form,* the proper object of our geometry. From this form we are enabled to contemplate the next higher form, or the form perpetually angular, which is the same as the *Circular* or *Spherical Form;* for this latter is more perfect than the other in this respect, that its circumference is, as it were, a perpetual plane, or infinite angle, because totally void of planes and angles; therefore also it is the measure of all angular forms, for we measure angles and planes by sections and lines of a circle. From these considerations we see, that into this latter form something infinite or perpetual has insinuated itself, which does not exist in the former, namely, the circular orbit, whose end and beginning cannot be marked. In the circular or spherical form, again, we are enabled to contemplate a certain higher form, which may be called the perpetually circular, or simply the *Spiral Form;* for to this form is still further added something perpetual or infinite, which is not in the former, namely, that its diameters are not bounded or terminated in a certain center, neither are they simple lines, but they terminate in a certain circumference of a circle or surface of a sphere, which serves it as a center, and that its diameters are bent into a species of a certain curve, by which means this form is the measure of a circular form or forms, as the circular is the measure of the angular. In this spiral form we are enabled to view a still higher kind of form, which may be called the perpetually spiral or *Vortical Form*, in which again something perpetual or infinite is found which was not in the former; for the former had reference to a circle as to a kind of infinite center, and from this, by its diameters to a fixed center as to its limit or boundary; but the latter has reference to a spiral form as a center, by lines perpetually circular; this form manifests itself especially in magnetic action, and is the measure of the spiral form for the reason above mentioned concerning inferior forms. In this, lastly, may be viewed the highest form of nature, or the pereptually vortical form, which is the same as the *Celestial Form*, [that is, the psychical, or superspatial form,] in which almost all boundaries are, as it were, erased, as so many imperfections, and still more perpetuities or infinites are put on; wherefore this form is the measure of the vortical form, consequently the exemplar or idea of all inferior forms, from which the inferior descend and derive birth as from their beginning, or from the form of forms. That this is the case with the formations of things will be demonstrated, God willing, in the doctrine of forms, and the doctrine of order and of degrees adjoined to it. From this form those faculties and virtues result, by which one thing regards another as well as itself, nor is there anything but what consults the general strength and concord, for in that form there is not given any fixed center, but as many centers as there are points, so that all its determinations, taken together, exist from mere centers or representations of a center, by which means nothing can be respected as proper to it, unless it be of such a quality that from what is general, or from all the centers, which taken together produce what is general, it may inflow into itself as a similar center, and may reflow through an orbit for the benefit of all, or into what is general. This indeed must of necessity appear strange at first view, because it is fetched from far beyond the objects of our sight; nevertheless, that the case is so, is clear from a consideration of all phenomena traced up to their causes and their principles; especially from the animate body, where such an arrangement of parts is everywhere to be met with that while each is a center in itself it is yet related to the terminations of near or remote parts in a kind of circumference, diameter, or axis; the eye presents to us a still more evident idea of these phenomena in the ether modified by rays." (N. 6, note b, new English edition, p. 12-15.)

In strictness the "celestial" form is applicable to the spiritual world only, as is evident from details given in Swedenborg's work on *Heaven and Hell;* but at the time this was written, such knowledge had not been acquired.

The last part of the citation has already been quoted, as well as illustrated in Chapter I where also something concerning the doctrine of "Degrees" will be found.* Obviously, the statement is no more applicable to the stellar systems with which the quotation begins, than it is to the wonderful things to be known concerning the relations of the atoms; for Swedenborg has assured us that "there is no difference between the maximum of space and the minimum of space." (D. L. W., n. 155.) The mere bigness of a galaxy is of no account if no new principle is involved, or if the bigness consists in an endless repetition of similar forms. But there is something new in the galactic complexes, and this is their control and ordering for Divine ends of a higher law, a psychical law, which enters into nature and substitutes humanistic conceptions for a soulless geometry. Elsewhere, in his theology, Swedenborg uses the word "celestial" for the highest degree of spiritual life. This is not its meaning here; but the admission of something spiritual is implied in a form "by virtue of whch one thing regards another as itself." It seems to me that the modern term "psychical" supplies the desired word.

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* A further analysis of the work from which this is taken, (The Worship and Love of God) may be seen in The New-Church Review for July, 1914, pp. 414-428.

The succession of forms—angular, spherical, spiral, vortical, and "celestial"—is defined in terms wholly geometrical; and the last, while it is applied to the heaven of stars and may be interpreted to mean the grand aggregation of galaxies, the hugest "form" in nature, is not the supreme natural form. That distinction must be reserved for the human body. But that form originates in a spiritual organism which is above and beyond nature. Still there must be a connecting link between the two realms, and this border, or *limbus* as Swedenborg calls it, is precisely that border region of which Sir William Barrett writes in his book, *On the Threshold of the Unseen,* and to which the name of "psychical" has recently been given. By limitation, the psychical defines or circumscribes the spatial realm which is that of the starry heavens. But this does not mean, as the groping guesswork of the materialistic thought of today, unable to conceive of anything that is *not* material, surmises, that the life after death is to be conducted in a "realm beyond the stars." Destructive of all truly spiritual thought, this attempt to conjure up an abode of the blessed, a paradise, in the unoccupied spaces beyond the stars, violates the laws both of nature and of spirit. Space is not infinite. There is no space which is not filled with the universal atmosphere out of which stellar systems are formed

Swedenborg's conception will appear if we notice the significance of his use of the word "perpetually." He applies it to successively higher orders of geometric form An angle which increases *perpetually* maps out a never-ending circular revolution. The circle is a simple line—a curve of definite radius. Let the radius increase *perpetually*, and gradually, or by infinitesimal successive additions related according to some mathematical law, and we have a spiral curve which sweeps out a progressively enlarging plane area. If the plane spiral rotates *perpetually* about a diameter or some other line in its plane, a new figure, a vortex, is traced in tri-dimensional space. There may be reciprocating spirals, and reentering vortices, or vortex-rings; but these do not give a limit to space. In order that space shall be limited, it must receive a fourth dimension, inconceivable to the mind that thinks only in terms of three dimensions, but capable of rational and mathematical presentation. In order that the vortex, like the previous forms, shall progress *perpetually*, it must proceed into a new order of form by the addition of a fourth dimension to space, by which entrance is made into the super-space of the spiritual world. The experimental evidence of the existence of this superspace has been given in Chapter VII. This fourth dimension* adds wonderful new properties to supernormal existence in the spiritual world. At the same time, it limits natural space, which does not extend to infinity, but returns into itself. The "perpetually vortical" form does not exist in nature unless as above noted, on the borders of nature to keep all in harmony, but Swedenborg says that it is the form of the least components of the universal aura of the spiritual world.

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*The "fourth dimension" has been given mathematical form in the writings of Riemann, Gauss and Simon Newcomb. Lorentz and Einstein give a mathematical-metaphysical tinge to the idea. A more readable account and one which is not so far from Swedenborg's conception is to be found in the "Tertium Organum" of Ouspensky.

The vortical form is pre-eminently the form of the magnetic aura of the natural world, and of the electric particles which are formed out of it, and whose circulation is always attended by magnetic vortices. But no element or substance can pre-empt any of these forms of motion. The particles of solids have rectilinear thermal vibrations which may be described as "angular," but most, and possibly all, solids *flow* if suitably confined and subjected to sufficient pressure. Both liquids and gases can receive vortical motions in masses of some magnitude. The atoms of solids, liquids and gases are spherical; and circular motions in the form of waves glide over surfaces of either air or water when rubbed by adjacent layers moving with a different velocity. Motion in a logarithmic spiral appears to be characteristic of the galaxies. Motion along a spiral curve attends indraught of air around the center of a tropical cyclone, though the movement is considerably distorted by the onward progression of the disturbance. Spiral volutes also appear in the side branches of certain high-tension electric discharges in air—a form which is probably due to the extreme viscosity of the highly heated electrified air.

The subject of Form is treated at much greater length in Swedenborg's posthumous work on *The Fibre,* but without adding anything essential to the above quotation from *The Worship and Love of God.* In fact, in some respects the treatment is less satisfactory. In note 264a of *The Fibre,* the remark is made, that "when we ascend above the circular form the ideas of our understanding enter as it were a kind of shade." Swedenborg's own ideas on the subject were certainly hazy. The treatment in "The Fiber" is largely metaphysical. He refers often to the sayings of Aristotle, Plato and Wolff, which were as vague as his own. In attempting to give a geometrical form to his thought, he is far from clear. For example, he says: "The circular form is voluble and rotable only around its axes or diameters, while the spiral form is voluble and rotable around a center; which central fluxion or gyration is the same as a perpetuo-axillary or truly spiral gyration" (*Ibid.*). What he has in mind (though he does not say so) is a reciprocating spiral in which the motion flows from a center to a limiting circumference and back to the center, with perpetual repetition. An example of the figure described by such a motion is given in my notes to the *Principia* (Fig. 1*a*), which conforms to what Swedenborg says the motion must be. His own figure does not agree with his specification. In circular motion the center is fixed and so is the length of the radius, and there is no approach to or recession from the center. In the spiral, both the center of motion and the radii are perpetually varying. The wording of the first part of the quotation can only mean, that a circle having been drawn, its plane may be rotated about any diameter of the circle as an axis of rotation. But precisely so can the plane of the spiral be rotated. This is obviously not what he wants to say.

Even worse is the passage in note 264*c*: "For spirals may be designated as circular, elliptical, parabolic, hyperbolic, geometric, arithmetrical, etc., since according to the nature of the spiral, there is formed on the inside a central globule or nucleus consisting of one of the above mentioned forms consisting of one of the above mentioned forms, and to this the external form corresponds." This is not so. The spiral, as usually defined in geometry, is a curve lying in a plane surface, though varieties of the figure may be inscribed on a spherical, conical, or other surface. But it has no "central globule or nucleus," nor is there such a thing as a parabolic or hyperbolic "globule," for the parabola and hyperbola are not closed curves. A paraboloid of revolution is necessarily a truncated figure on whose curved surface a variety of the spiral may be inscribed, but it has no "parabolic nucleus." The spirals which are called parabolic or hyperbolic are named after the functions from which they are derived, but their figures have not the slightest resemblance to the corresponding conic sections.

The doctrine of forms which Swedenborg is struggling to elucidate, may be illustrated by the relationship between certain geometrical figures, but the latter should not be taken too literally or absolutely as defining the form. Thus there is a series in world-forms, beginning with the angular fragments which we call meteorites, continuing in the spheroidal bodies of suns and planets, and ending in the spiral forms of the galactic aggregations of these. Here there is a sequence of forms, but elsewhere a single form may unite diversified entities. The least particles of the atmospheres have the spherical shape, whether they belong to air, ether or aura. But the structure and fields of force of these particles, which are their essential forms, are quite different. The sphere is found equally in the sun and the dewdrop. They have nothing else in common. Vortical motion can be produced in water and air as well as in the magnetic aura; but liquid and gaseous movements of this sort are transient on account of the great friction which they develop. The aura is especially the vortical element because it has almost no friction and its vortices can endure. It will not do, however, to pick out a particular form of motion and pre-empt it for some single department of creation. The scheme will not work. What we do find is, that as we ascend towards the inmosts of nature, the interrelationships become more wide-spread, more universal. This relationship and interaction of parts makes the "form" which Swedenborg is trying to visualize, and it is a grand conception, however imperfect may be our grasp of it.

There are forms which are still higher than those of nature and which are not amenable to the laws of simple geometry. As the senses do not exist outside of the body, but within the sense-organs, nerves and brain-tissue, whence impressions are conveyed to the spiritual organism; and as touch, taste and smell are produced by contact with material substances, attended by complex changes of form in interior organs; so thought and affection are spiritual substances which affect or are received by the organs of the spiritual body. These forms are human and organic. They are *multi*form in their modes of action, but always on human models. These forms descend into the natural degree and exercise control there in their own right, but by means of the intermediate psychical plane of thought and activity, which divides the spiritual from the natural and yet conjoins them. Swedenborg tells us that the conjunction is effected by correspondences, and postulates a limbus formed from the purest substance of nature and acting as a go-between. Psychical research is rather vague as to ways and means, but suggests that a "psychic" is a peculiarly sensitive instrument, capable of responding to messages telepathically transmitted either from discarnate spirits or from people on this side the veil.

The heavenly form permeates the earthly. To pass from one to the other needs but the turning of a switch on a track already prepared, if we have adopted correct values.

We know, or ought to know, that "every bush and tree's on fire with God," that every material or menial service done for another's help or comfort, may be an act of worship, if we seek the face of God looking through our neighbor's eyes; for "inasmuch as ye have done it unto the least of these My Brethren, ye have done it unto Me."

For the teaching as to truly living forms we must turn to the Writings:

"There are two forms into which the operation by influx takes place, the vegetable and the animal form. . . . All the departments of either kingdom are known to possess many things in common. . . . All animals, great and small, derive their origin from the spiritual in the outmost degree, which is called the natural; man alone from all three degrees, the celestial, spiritual, and natural. . . . But plants derive from the spiritual out of which they spring that they are uses, while animals derive from the spiritual out of which they spring that they are affections and appetites." (*Divine Love and Wisdom*, n. 346.)

The forms of plants, though derived from the spiritual Sun and thus complexly organic, are yet called "natural" because in the vegetable kingdom and also in some of the lowest or most plant-like animals, such as the fixed corals with their branching stems and flower-like polyps, the radial plan prevails, which is one of the natural forms, the form in which light sends out its radial propagations. Plants also grow by reception of light, and as light corresponds to truth, plants correspond to knowledges and perceptions of truth.

In *True Christian Religion* (n. 585) we read: "That the living growth not only of trees but also of all young growing sprouts corresponds to human prolification, has been affirmed by many of the Learned; I may therefore advance something of importance on this subject by way of conclusion to what has already been said. In trees there are not two Sexes, a masculine and a femine, nor in any other subject of the vegetable Kingdom, but everything there is masculine; the Earth alone or the soil is the common Mother, and is thus as if Woman; for it receives the seed of all fruits, opens it, carries it as it were in the womb, and then nourishes and brings it forth—that is, brings it out to the light of day, and afterwards clothes and sustains it. When the earth first opens a seed, the latter begins with the root, which is a kind of heart; from this it emits and transmits sap like blood, and so forms as it were a body provided with limbs; its body is the trunk itself, while the branches and their branchlets are its limbs. The leaves which it puts forth immediately after its birth, serve as lungs; for as the heart without the lungs does not produce motion or sensation and thereby vivify man, so the root without leaves does not cause a tree or shrub to vegetate. The blossoms which precede the fruit are means for purifying the sap, the tree's blood, for separating its grosser from the purer elements, for forming a new little trunk for the influx of these purer elements contained in the bosom of this sap, through which trunk the purified sap inflows and so initiates and gradually forms the fruit, which may be compared to the testicles in which the seed is perfected. The vegetative soul which inmostly governs in every particle of sap, or its prolific essence, is from no other source than the heat of the spiritual World; which heat, because it is from the spiritual Sun there, aspires to nothing but generation, and a continuance of creation thereby; and because it essentially aspires to the generation of man, it communicates to whatever it generates a certain resemblance to man. Let no one be astonished at the statement, that the subjects of the vegetable Kingdom are masculine only, and that the Earth alone or the soil is like a common Mother, or is feminine as it were. The matter may be illustrated by something similar among Bees; they, according to the observation of Swammerdam, reported in his *Biblia Naturae*, have only one common mother, from whom is produced the offspring of the entire hive. Since there is but one common mother for these insects, why not the same for all plants? That the Earth is a common mother may also be illustrated spiritually, and it is so by the fact that the Earth in the Word signifies the Church, and the Church is a common Mother, as she is also called in the Word."

The whole of this passage which is introduced into teaching concerning the new birth of regeneration, of which the first step is instruction in the knowledge of spiritual truth, is obviously to be taken symbolically. The Church (Terra, Mater, Foemina) can nourish the domain of truth (*Regni vegetabilis*), in which are things of the understanding (Masculum.) See A. C., n. 54. Swedenborg is not denying that there is something resembling "human prolification" in the life of plants, in fact the passage begins with this very statement that there is in plants something which "corresponds to human prolification," and he is illustrating the New Birth, "as it were" from a "womb," and not, of course, in any literal sense, but in the loving care of the Church (*Mater*).

The trees appear to be considered spiritually like those trees of knowledge or of life in the Garden of Eden, which never grew in any material soil; and yet, since there is a direct appeal to natural science, the literal statements can not be overlooked. As such, they evidently need modification.

In Swedenborg's time the question whether plants have sex was a debated one, as is here affirmed, and although his kinsman, Linnaeus, had settled it in the affirmative at the time this was written, the answer had not been generally accepted.

Swedenborg knew that plants correspond to knowledges of truths, or that their spiritual causative principle resides in the human understanding. In the Most Ancient Church "they called the understanding in the spiritual man male, and the will female; and when these acted as one they called it a marriage." But it does not follow from this that all plants are males. Animals are forms of affection but are not on that account female only.

Animals and plants embody functions which spiritually relate to the will and understanding respectively. If Swedenborg had confined himself to correspondential statements, he would have been within his rights. But when he appealed to natural science, and to moot questions in science which have now been decided adversely to his contention, he laid himself open to criticism.

Strictly speaking, the plant is not an individual, but a community. "As the days of a tree are the days of My *people.*" The leaf is the individual plant. Swedenborg's analogies can not get rid of this fact. If the leaf were merely an organ, it could not take root when planted in the ground as it does in a number of plants. While it may be true that most of the leaves on a plant have (correspondentially) the male function, in that they act as lungs and like the lungs of an animal correspond to the intellectual or male principle, yet certain specially developed leaves become carpels, or seed-bearing individuals, and these are female just as much as any animal individual is female.

We can get further light, or at least illustration, from special cases. In the beehive, where there is division of labor and diversity of function, the great majority of the bees are workers, or undeveloped females. By special feeding, a grub which would otherwise produce a worker, can have its size increased and the reproductive organs developed so as to grow to be a queen and, after fertilization by a drone, may become the mother of a hive.

In a tree, the vast majority of the individual leaves are undeveloped males. Some of the innermost petals of the water lilies become partially or wholly converted into stamens, or sexually developed males, confirming the fact that the normal sex of the floral leaflet, or individual, is male.

The point is this. The Vegetable Kingdom from its inherent spiritual correspondence tends to produce males as a rule, and females only exceptionally; while the Animal Kingdom by its spiritual correspondence has a tendency to produce an excessive number of females in certain highly specialized animals; and as Swedenborg makes a comparison between plants and bees, perhaps the more legitimate conclusion would have been, not a denial of sex of either sort, but the affirmation of a preponderance of one sex.

Both plants and animals may, in some cases, be propagated without sexual reproduction. Thus cuttings of some plants, when placed in moist earth, take root and grow. Similarly, some of the lower animals, such as the Hydra, may be cut in halves, and if the separate pieces are replaced in water, they will develop into complete animals. The moist earth or the water are simply the materials needed to support growth. The Earth is no more the "mother" of plants than it is of all living creatures. The analogies pointed out in this passage give a useful lesson, but need not be taken too absolutely.

In comparing the seeds of plants to the male element in animals, which has been named semen from the Latin for seed, Swedenborg is merely making a play upon words. Because the male propagating fluid has been named "semen," or seed, does not identify it with the *seeds* of plants whose analogue is the fertilized ova of an animal. The male semen is wholly analogous to the fluid which passes through the pollen tube and fertilizes the vegetable ovule in the carpel of a plant. Nobody says that an egg is a bird. But both eggs and seeds contain *embryos* which are miniature animals and plants, capable of development to their perfect form. The whole subject has been admirably discussed by Rev. Charles A. Hall, F.R.M.S., in The New-Church Review for April, 1922.

A truer picture of Swedenborg's essential thought is given in *Divine Love and Wisdom,* n. 316, which says nothing about plants being male. In this and the connected passages, the subject is the "forms of uses," and these forms are declared to be such as can receive spiritual heat and light from the spiritual Sun. Such are the forms of the generative soul from which is all growth and without which there could be no life. To this I will add the following quotation:

> There are two general forms, the spiritual and the natural; the spiritual such as is that of animals, and the natural such as is that of plants. . . . The forms of the animal kingdom, which in one word are called animals, are all according to the flux of spiritual substances and forces; which flux, from the endeavor which is in them, is into the human form, and into each and all things of it. . . . It is from this that the universal Heaven is in such a form, and that all Angels and Spirits are in such a form, and also all beasts, birds and fishes. This animal form derives the endeavor to such things from the First . . . Who is a Man. . . . The other form, which is the natural form, and in which

are all plants, originates from the endeavor and the derivative flux of natural forces, which are atmospheres, and are called ethers, in which this endeavor is present from the determination of the spiritual forces, which is into [or towards] the animal form. . . . That this is its origin, is evident from . , , some likeness of the animal form appearing in them. That all things of nature strive after that form, and that the ethers make an effort to produce it from what is spiritual impressed and as it were implanted in them, is evident from . . . the universal vegetation on the surface of the whole Earth, also from the vegetation of minerals in such forms in mines . . . from the vegetation of calcareous matter into corals in the depths of the sea, and even from the forms of snowflakes which are emulous of plants." (From the paragraphs "Concerning the Athanasian Faith" and other topics interspersed in the MS. of the "Apocalypse Explained," n. 1208.)

The animals in all of their innumerable forms have one thing in common, namely, the possession of a stomach for the reception of food, whereby they distinguish between the *ego* and the *non-ego,* and thus gain possession of consciousness and desire, together with the power of voluntarily seeking their food and *choosing* it. If the animal does not possess a stomach (the amoeba, for example), it proceeds to improvise one and wraps its body around the chosen food particle. Whatever tendency the plant may have for imbibing special nutriment is mainly a mechanical process. The motion of the leaves of the sensitive plant is involuntary. It can not alternate between bravery and timidity.

The human body is made out of natural substances and shares their forms; but its own special forms are not the simple geometrical ones of inorganic nature. In the human body the spiritual dominates and imposes its own forms upon those of nature. One of the special features of the forms of human, or organic activities is that they are not confined to single points or separate loci, but that they interact, spread, communicate and mutually assist the activities of interrelated forms—"all for each and each for all;" and as this is characteristic of the heavenly life, the form is spiritual, at least in origin, whether it is manifested in the spiritual or the natural world. The human form, organized for the production of uses of every kind, is primarily a spiritual form, arranged in three degrees of ascending order—natural, spiritual, and celestial—whose ultimates are action, thought, and affection, together with vessels for the reception of life and its substantials. The initiament of the human body is by means of vessels—nerve fibers from the brain, arteries and veins from the heart.

By "form" we mean not only external shape, but also internal structure and its function. In the body are interwoven seven distinct physical systems:

(1) The brain and nervous system (including the essential sensitive portions of the organs of sense). The brain produces the pure nervous "fluid," * or "animal spirits" of the old anatomists, which fills the medullary fibers of the brain and according to Swedenborg comes from the least cells of its cortex, and which vivifies the blood and every organ of the body. The forms of the inner structure of the brain are most wonderful. The circumvolutions of the fiber within the cells of the cortex remind us of the motion in a vortex, and Swedenborg suggests that the vortical magnetic atmosphere "would seem to produce reasonings in the natural mind."

(2) The heart and lungs with the circulatory system of vessels wherein the red blood courses (including the spleen and kidneys where the blood is regulated and purified.) No city has such a splendidly regulated pumping station

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* Concerning which see the suggestion near the end of Chapter VII, page 576.

and distributing system in its water works, for the Engineer is He who "watching over Israel, slumbers not nor sleeps."

(3) The lymphatics and their glandular system, wherein is the lymph from whence come the white corpuscles of the blood which stand as guards against contaminations, and repair the ravages of a too strenuous use of bodily parts.

(4) The stomach and intestines, or the digestive organs including salivary glands, liver and pancreas.) These are the store houses and receptacles of fluid energy whereon the the blood calls for the renewal of its strength.

(5) The muscular system, releasing the stored-up energy for use, and constituting, with the bones, the most perfect of engines.

(6) The membranes—external skin, internal tunics, aponeuroses, pleura, etc., providing containing vessels, separating partitions, and restraining walls.

(7) The osseous system—the foundation stones of the structure and the resistent member of its machinery.

"Bones in the Word signify truth, and in the opposite sense falsity. . . . Truth supports good as bones do the flesh." (A. C., n. 9634.) Every organ in the body, even the lowest (the bones), is a form of some use. A man of flabby morality, who yields to the slightest temptation, may have "flesh" and the lusts of the flesh, but we say of him: "He has no back bone."

The soul gives form to the body. "The use," says Swedenborg, "had existed before the organic forms of the body came forth; and the use produced and adapted them to itself, and not the converse. But when the forms have been produced, or the organs adapted, the uses proceed from them; and then it appears as if the forms or organs exist before the uses; when yet it is not so; for use inflows from the Lord, and this through Heaven, according to the form, according to which Heaven has been ordinated by the Lord; thus according to correspondences." (A. C., n. 4926.)

"What is the form of power but the human arm with the will in its muscles? . . . Let us run along the arm, from shoulder to fingers, to notice how the emblem offers a true habitation to the idea. First, man is a living *force,* a lake of energy, from which the arm pushes forth as a river of waters of works; for force is the trunk and body which urges at the back of power. Next, the shoulder is proper *power,* the place where will meets force, and where power is born. Again, the arm is *strength,* where the biceps and triceps which are the blacksmiths of action live; the men of iron know where their iron lies. The forearm is *toughness,* or the home of sinewy power. The wrist is *flexibility,* where sleight of hand begins. The palm of the hand is *possession,* or the power of having; it itches for the finger-tips which give it the power of holding. The grave thumb is *firmness* or steadiness, and it stands short and sullen among the fingers, which are of the rapid temperament of *skill.* In the closed fist again the emblem of force comes forth, and completes the circle of this series of powers." (Dr. J. J. Garth Wilkinson in "The Human Body and Its Connexion with Man," p. 308-9.)

The human form is a universal form, linking all parts of the universe into a whole. The lower forms are limited. The human form has no limit save the Divine, which it can emulate, but to which it can never attain.

The spiritual world has its atmospheres and substances, and these have their own forms, distinct from those of nature; but owing to the discrete degree which separates nature from spirit, these can only be described by analogies.

"There are atmospheres in the spiritual, just as in the

I. THE DIVINE WORLD

Substance { Divine Love
Divine Wisdom
Divine Power } = God-Man. Form = the Divine Human. Proceeding = the Spiritual Sun and its radiant belts.

II. THE SPIRITUAL WORLD

ATMOSPHERES

1. Spiritual ethereal of highest heaven.
2. Spiritual aerial of middle heaven.
3. Spiritual watery of lowest heaven.

Form = spiritual, or human: "The measure of a man, that is, of the angel."

Forms of spiritual atmospheric particles: "Like little infants." "Like horses and chariots." Like diamonds, precious stones, flowers, etc.

III. THE NATURAL WORLD

Form = radiant, or emanating from centers.

ATMOSPHERES

4. Aura (particles spherical)
5. Ether " "
6. Air " " .

SUBSTANCES

First element = electrons = vortex-rings of aura.

Second element = atoms = spherical vortices of electrons of nearly one hundred kinds.

Third element = lattice structures of atoms = crystalline space-lattices of atoms in fourteen forms.

A general view of the creation of forms exhibits a descending sequence and an ascending one:

The dispersal or disintegration of life from God to matter.

Descending. God
Spiritual Sun
Spiritual atmospheres ↓
Natural atmospheres

Ascending. Heaven
Human beings
Animals ↑
Plants
Earths
Sun

The integration or condensation of ascending life from body to soul

The Cosmos considered as a vast complex of uses, with innumerable suns, each sun like a particle, each galaxy a cell in a great organism.

natural world." (D. L. W., n. 176.) "The spiritual atmospheres are divided substances, that is, minute forms, originating from the Sun." (*Ibid.*, n. 174.) The difference between spiritual and natural atmospheres is that spiritual atmospheres are receptacles of Divine fire and Divine light, thus of love and wisdom, for they enclose these interiorly within them; while natural atmospheres are receptacles, not of Divine fire and Divine light, but of the fire and light of their own sun, which in itself is dead." (*Ibid.*, n. 175.)

In the spiritual world the forms of the human mind are of three orders which reside in as many atmospheres. "They who are in the third degree of love and thence of wisdom, live as it were in a pure ethereal atmosphere; they who are in the second degree of love and thence of intelligence, live as it were in a pure aerial atmosphere; and they who are in the first degree of love and thence of knowledge, live as it were in a pure watery atmosphere." (A. E., n. 832.) Here the several atmospheres, instead of subserving special faculties, appertain to the entire form of the life. Those spirits in whom only a lower degree of life is opened, can not breathe the purer atmosphere of a higher degree, because their forms are diverse.

The tabular form opposite will perhaps help to bring the order of forms and their succession before the eye.

FORMS AND THEIR SUCCESSION

A crystal has imaginary planes of symmetry which divide its form into halves of which each is the mirror-reflection of the other. According to the number of such planes which can be passed through a given crystal in different directions, crystals can be divided into seven groups. These are (1) the regular or cubic system; (2) the hexagonal system;

(3) the quadratic or tetragonal system; (4) the rhombic system; (5) the trigonal system; (6) the monosymmetric or monoclinic system; (7) the asymmetric or triclinic system. Each of these systems may be further subdivided into classes of which the total number is thirty-two.

From a different point of view, namely, that of internal structure, or atomic piling, with which, however, the origin of symmetry is really most intimately connected, fourteen (twice seven) different forms can be discerned. All of these forms rest upon purely angular considerations.*

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* Abundant instances of sequences of forms and properties in nature with seven as their complete or full number, have been given, and it will be seen that these are not hap-hazard or inconsequential recurrences, but are of the highest importance. But this can not be said of certain delusive attempts to reinforce the principle by bizarre or even erroneous applications which have no significance whatever. For instance, in the New-Church Messenger for December 8, 1920, the Rev. G. H. Dole attempts to draw an illustration from chemistry which is not warranted by facts. He says: "The chemist has found that like properties occur in periods of sevens, hence No. 8 would be the next element of like properties," etc. Unfortunately for Mr. Dole's illustration, the chemical properties in question recur after a sequence of eight examples, and the partial repetition of properties begins with the ninth member. The reason of this is explained above in treating of Langmuir's theory of valency.

Mr. Dole also tries to draw a parallel from the eight notes included in the musical octave, where the eighth tone resembles the first, but doubles its number of vibrations in units of time. Here there is more ground for such a comparison, but the chemical parallel is not as simple as he supposes, for, in addition to the error in regard to the number of elements in a chemical period, the notes of the common musical scale are arranged at intervals of two tones, half tone, three tones, half tone, while the differences of valency are all exact multiples of a constant quantity. There are no "half" electrons. Moreover, while our musical scale is most pleasing to cultivated ears and seems to be the one best adapted to the production of refined melody, it is not the only possible one (primitive peoples have used other scales) nor is it found in nature, for the birds do not sing according to its requirements.

It is noteworthy that the division of crystals into classes rests at bottom on the *internal* arrangement of their atoms, to which the external form is wholly subservient, for crystalline facets lie parallel to internal sheets of piling. The points to be noted in establishing the systems, are the relative lengths of the crystallographic axes, their inclination to one another, and the values of the interfacial angles.

In his *Principles of Natural Philosophy* (Part VIII), Swedenborg gives descriptions of eight different modes of piling. Some of these would not now be classed as distinct, and there are others which are not mentioned.

The seven crystallographic systems and the seven (if we omit the "noble" elements as having no valency) different kinds of valency in the chemical atoms, have their representative in the organic world in the seven anatomical systems of the human body. Whence comes this potency of the number seven? The assigning of the days of week to the seven bodies belonging to the solar system which are easily visible from our Earth, is a fortuitous astronomical procedure, which would not apply to the outer planets, possessing many more moons than we do, and requiring a longer week to give each one a day. The examples of sevenfold forms in the organic and inorganic worlds, on the contrary, are not a matter of chance, but rest upon profound philosophic principles. The deepest of these principles are spiritual. Was it foreordained that because this Earth was to witness the Incarnation of the All Holy, therefore His symbolic number was, from the beginning, blazoned on our skies? Possibly. But let us put this aside as a speculation which is not capable of verification. There are simpler reasons for the significance of the number seven and its forms, which are true for every earth in the universe.

The smallest number of straight lines which will enclose a plane figure, is three, making a triangle. Four equilateral triangles enclose a tetrahedron and are the smallest number of plane faces which will define a volume. Now truth is what we know about a thing. Even when genuine, truth is not the thing itself, but is a superficial view of the thing. Good, on the other hand, is solid substance, the *real* thing. Consequently, in spiritual correspondence, the number three stands for what is complete as to truth because it signifies all truths in the complex," A. E., n. 411; "three, in the Word, is predicated of truths . . . because 'three' signifies fulness; and spiritual fulness is formed through truths," A. E., n. 532); but the number four signifies the all of good ("the number four signifies all as to good," A. R., n. 348;" three is predicated of truths or falsities, and 'four,' of goods or evils," A. C., n. 10,624.) Hence seven, which is the sum of these numbers, signifies what is complete as to both good and truth, and therefore, by the conjunction of the two is represented what is holy from reception of life from the Divine. Here is the Divine signature written on the book of nature in its inorganic, as well as its organic forms. This signature of the forms of nature can not be counterfeited. This is no mere fanciful suggestion. It is demonstrable fact—the sign-manual of God.

If Divine law and order are to be seen in the lowest forms of nature, still more will they appear when we ascend to the inner chambers where life dwells. Treating of the human soul in his *Economy of the Soul's Kingdom* (Part II), Swedenborg says:

> Anatomy plainly shows that the first substance of the animal system, or the spirituous fluid, flows into all the other substances; for it enters all things as the first substance of its body, the only and proper animal substance, and the determining prin-

ciple; it is the form of forms of its body, by which and for which other substances exist in their own distinctive manner." (n. 243.)

But what is form?—This as well as other terms is distinctly explained by the doctrine of order, which as it ascends through degrees, so it arrives at higher abstractions. In the lowest degree, form means the structure of a body, both internal and external. 'The form of everything,' says the philosopher, 'is perceived by the sense of sight.' The form also means the structure of other things; and thus we speak of forms of government, forms of motion, forms of words, or forms of speech, etc. In a higher degree form means [mental] image, for such as it is successively represented to the ear or the eye, such is it simultaneously represented to the animal mind abstractedly from matter. In a still higher degree it means barely form, or according to some idea. . . . In a still higher degree it means the universe. (n. 244.)

Nothing in the created universe is anything except by its form; or what amounts to the same thing, there is nothing in the world but is a series or in a series. (n. 286.)

After all that has been said, it will be seen, I think, that Swedenborg's *Celestial Form* with which we commenced, is not just the arrangement of the stars in space and the general form of their motion, but it is the stream of the Divine Providence which views each thing, even the least in its connection with and relation to every other, and adapts them all to the weaving of a shining garment of law and order.

Beneath the shadow of Thy wings,
My soul shall dwell secure.

In the insect world we see remarkable changes of form. The caterpillar passes through the chrysalis and comes out a butterfly. Anatomy shows in the body of the lava a minute knot of air-tubes which grow rapidly during the chrysalis sleep; but it seems a miracle that, upon the awakening, those beautiful wings can unfold, supported by a network of tracheæ whose pattern is always the same for each kind, the whole exquisitely colored. It is the emblem of the new life of the spirit uplifted above what is low and gross. "Ye *must be born again*," says Jesus. The Divine life, flowing into nature, accomplishes the seemingly impossible change of form from the crawling worm to the flying insect; and just so, the Lord of the Ressurrection sees in each one of us a potential angelhood.

In attempting to elucidate the subject of form, I am painfully aware of the inadequacy of these explanations. My thoughts seem like clumsy caterpillars trying to unfold their wings before the time of emergence. Let us hope that some day the poet will appear who can describe these things with the brilliancy of the irridescent wings of the butterfly. As Goethe makes his Faust to say, when viewing the glory of the sunset:

> "O for a wing to lift and bear me on,
> And on to where his last rays beckon!
> Then should I see the world's calm breast
> In ever lasting sunset gleaming
> The summits all on fire, each valley steeped in rest,
> The silver brook to golden rivers flowing."

The time comes when we long for the New Birth. Let us reverently pray that our Lord will pardon our frailties and lead us into the Beauty of Holiness.

The *Spiritual Diary* (n. 222) speaks of *four* natural atmospheres:

> There are four natural spheres which originate from the sun. The atmosphere that produces hearing is known. A purer atmosphere, separate from the aerial one, is what produces sight, or visual images, . . . How far this atmosphere penetrates into

the natural mind, and whether it presents material ideas, as they are called, or fancies and imaginations, can not as yet be so well established, but from many things it appears probable. This, then, must be the first atmosphere which reigns in the natural mind. Another atmosphere is a still purer ether, and is that which produces the forces of magnets which reign, not only about the magnet in particular, but also around the whole globe. . . . It produces . . , many things . . . respecting the magnetic inclinations and declinations. This (atmosphere) would seem to produce reasonings in the natural mind with which, however, for them to live, the Spiritual must be present; as it must be with the sight, and every other sense, for them to perceive. The purest ethereal sphere [fourth atmosphere] is that universal (sphere) in the universal world, which is presented about the reasonings of the same mind. Hence that mind is called the natural mind, and its interior operations, when perverted, are called reasonings;* but when according to order, simply reason, which is a species of the thoughts arising from spiritual influx. These spheres are of the sun, and may be called solar, and thus natural.

Here the fourth atmosphere or the one above the magnetic aura appears to belong to the intermediate, or psychical state. If this is to be accepted, there are seven atmospheres. But elsewhere (as in *Last Judgement,* posthumous, n. 313) Swedenborg speaks of six atmospheres, three of them natural, and three spiritual. Hence he seems to have been in doubt whether to call this psychical intermediate an atmosphere, or to include its activities with those of the aura. It is perhaps to be compared with radiant ether-particles, which are discrete entities, carrying with them special forms of motion, but not constituting a continuous atmosphere. Similarly, each human *limbus* defines and confines a special individual human form and quality, much as an ethereal sheath about an individual electron shares its motion and can carry an image of it away unchanged. The *limbus,* therefore, is a sort of limiting skin or sheath, which takes its form wholly from that which it surrounds and has no form of its own.

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* Reasonings or ratiocinations—here we have a strictly scientific term to denote the workings of that mind which builds its house upon the shifting sands of falsity. But where these workings are based on the firm rock of truth, the mind dwells in an atmosphere of pure reason.

Finally, in the Lord is a Divine form which infinitely exceeds the spiritual form in perfection. "From the creation of the universe . . . it may be seen that the Divine love which is life itself, and which is the Lord, is in the form of forms of all uses, whch form is Man." (*Divine Love,* VIII.)

What then is the Divine form? Guided by revelation (for, of ourselves, we can know nothing in such high matters) we affirm that the Divine form is that Word of Life manifested by the Incarnate Jehovah in His Jesus-personality, now transmuted into all-powerful Divine-natural substance, wherewith He will provide a new cosmic organism for the reception of His inflowing Life and Love. His coming to earth a second time as Son of Man, that is, in a Divinely opened Word, is to eventuate in a Redeemed Human Race and a New Social Order. The manifestation of this Divine form in ultimates ("on earth, as it is in Heaven") implies first a Last Judgment upon existing social *dis*order, and a rejection of the same, before the New Earth, wherein dwelleth righteousness, can appear and be ready to receive the descending New Heavens.

It should be the supreme use and prerogative of those to whom the new truths of the opened Word have been entrusted, to prepare the way for the appearing of the Son of Man by "hearing His voice," hearkening to His commandments, and doing all in our power—politically, economically, and naturally, as well as spiritually, to shorten the birthpangs (Isaiah, xiii, 8), and alleviate the "distress of nations" (Luke, xxi, 25) attendant upon that Coming. "Why do ye not understand my speech? Because ye can not hear My Word," said Jesus (John, viii, 43.)

> "God walked alone unhonored through the earth;
> For Him no heart-built temple open stood,
> The soul forgetful of her nobler birth
> Had hewn Him lofty shrines of stone and wood,
> And left unfinished and in ruins still
> The only temple He delights to fill."

> And Jehovah saw it, and it displeased Him that there was no justice. And He saw that there was no man, and wondered that there was no intercessor. Therefore His own arm brought salvation unto Him. (Isaiah, Lix, 15-16).

If anyone will keep the Divine precepts (for this is meant by "hearing"), he can receive illustration and know something of that marvelous form which fills the Heavens with glory.

"The Church and Heaven," says Swedenborg, "are from the Lord as One Man, whose forms, which are called higher and lower organic forms, and also interior and exterior ones, are made of all who love uses in doing them; and the uses themselves compose this Man; because it is a spiritual Man, which does not consist of persons, but of the uses in them . . . and as this Man is the proceeding Divine from the Lord, and the proceeding Divine is the Lord in Heaven and the Church, it follows that all these are in the Lord." (*Divine Love*, xiii.)

"The angelic Heaven, viewed in itself, is from the divine which proceeds from the Divine Human of the Lord. Consequently, the angelic Heaven in its whole compass is as one man; wherefore this Heaven is called the Greatest Man." (Ap. Ex., n. 391.)

"This Grand Man [on earth] became entirely perverted by falls." (*Spiritual Diary,* n. 488.) Until this perverted form is removed and the true form of social order is restored, "the whole creation travaileth in pain."

The Lord "gives to those who are in a life of love, to think of God under a human form, and God under a human form is the Lord. Thus do the simple think in the Christian world, and thus also do the gentiles think who live in charity according to the principles of their religion. Both the former and the latter are astonished when they hear the learned speak of God, as not to be perceived in any human form, knowing that, in this case, they can not see any God in their thought, and hence that they have but little faith in the existence of a God, inasmuch as the faith which is a faith of charity desires to comprehend in some manner what is believed, for faith is of the thought, and to think what is incomprehensible is not to think, but only to know and thence speak without any idea. The Angels who most excel in wisdom think no otherwise of God than as in the human form. To think otherwise is a thing impossible to them, because their perceptions flow according to the form of Heaven, which form is human from the Lord's Divine Human principle; and likewise because the affections from which their thoughts are dervived, are from influx, and that influx is from the Lord." (*Apocalypse Explained,* n. 392.)